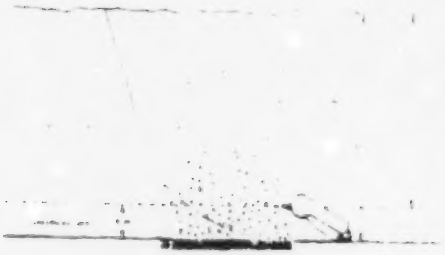
SEDIMENT DATA
USERS MANUAL
ONTARIO

NETWORK

SAMPLING



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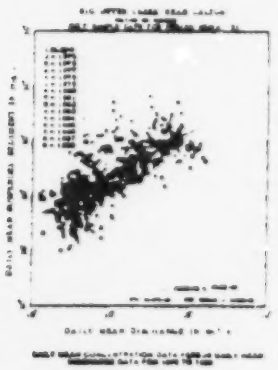

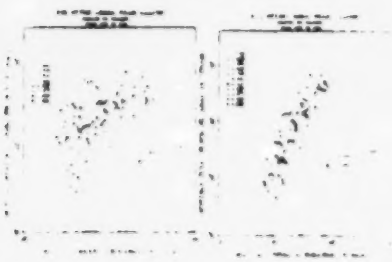

PUBLICATIONS

Sediment Data

Ontario

Données sur les sédiments

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ONTARIO SEDIMENT DATA

- A USER'S MANUAL

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1.0 INTRODUCTION

1.1 Need for Sediment Data

Suspended sediment data are being used and are required in Ontario for the exploration of a wide variety of topics, involving both quantitative and qualitative issues. A recent study of users and their needs (Conservation Management Systems, 1986) revealed that a number of studies relate to the quantity of sediment deposited in channels, ponds, reservoirs, harbours and lakes. However, most sediment data users are more interested in the quality of the suspended materials being transported through stream and lake systems. Further, the issues being addressed by users reveal a focusing of attention on where the sediment is coming from, what it is carrying in the form of potential contaminants, where it is going, and how both the volume and quality of sediments affect downstream water quality and quantity.

Work relating to sediment sources in Ontario, and to their management, deals almost exclusively with suspended sediment, the transport capacity of such material for various chemical pollutants being of prime concern. There continue to be numerous requests for information to ascertain the absolute and relative quantities of sediment emanating from agricultural, forested, and urban areas; from streambanks and ditches; and from specific locations such as construction and power project sites. Questions of interest include: What are the sources of sediment, and sediment-associated contaminants (e.g. phosphorus, heavy metals, pesticides)? Are the sources localized or broadly distributed on the landscape? Where sediment loads and/or associated contaminant loads are deemed to be excessive, what remedial measures are most effective? Where should these measures be targeted for maximum impact and minimum cost?

The role of suspended sediment as a transport medium for contaminants is very clearly a major issue in the province. There is concern about the nature and magnitude of contaminant loads associated with suspended loads; and there remain questions regarding the relation of sediment characteristics to contaminant transport, including the role of sediment as a source and/or sink for contaminants. Determining the impact of suspended sediment on pollution, and of pollution on suspended sediment,is a requirement for studies being undertaken by a number of users of sediment data.

There is considerable interest in the development of a global perspective of the spatial and temporal distributions of sediment yield in the province, and in the development of sediment/streamflow models. Input from sediment data users has clarified that these are issues, and that there is now a need to link such developments to the distributions and movement of other water quality parameters, such as nutrients, metals, dissolved solids, oxygen-demanding materials, and toxic organics.

Most of the issues identified by Ontario sediment users have been precipitated by downstream problems brought about by the quantity and/or quality of suspended sediment arising from and transported through the contributing watershed. Persons are requesting data to quantify the volumes of sediment available for deposition in (i) stream channels - to determine the possible needs for dredging and the possible impact on the populations of fish and stream biota; (ii) ponds and reservoirs - to determine the rate of decline of available flood storage and the life expectancy of the site; (iii) harbours - to determine the need for, location, and cost of dredging; and (iv) the Great Lakes - to determine temporal and spatial loading patterns.

Concentrations of suspended sediment, and their variability in time, are also quantities being explored by engineers designing and operating water supply intakes and by persons concerned about the improvement of stream ecology. In addition to these quantitative issues, the quality of the sediments transported and/or deposited in stream channels, ponds, reservoirs, harbours, and the Great Lakes is of increasing concern to both managers and scientists. All of these downstream problems require resolution of many of the upstream watershed issues and/or accurate information regarding the downstream conditions relating to sediment and associated variables of interest.

Although information available regarding current and future sediment issues has been predominantly influenced by

Although information available regarding current and future sediment issues has been predominantly influenced by input from persons interested in the southern part of the province (i.e. peninsular Ontario), issues raised by persons from northern Ontario have not been noticeably different. They too are involved with sediment quantity and quality matters from the sources to the downstream consequences. Understandably, the importance and management of forest source areas are of prime interest in the north, as opposed to the impact of agricultural areas in the south.

It should be noted that a considerable number of people are making use of Ontario sediment information, and that a great many and a wide variety of groups are involved. Most of the user groups are government based (federal, provincial, and municipal), and virtually all users are exploring sediment data on the basis of government funding (i.e. as civil servants, consultants or government contracts, or academics involved in research funded by government grants).

Therefore, it can be concluded that there is a strongly expressed need for a sediment data base in Ontario which allows the exploration and resolution of a wide variety of sediment related issues. These issues relate to both sediment quantity and sediment quality; and attention is being and needs to be focused on sources of sediment, associated contamination, transport and deposition mechanisms, and the manner in and extent to which the volume and quality of sediment moving downstream affect water quantity and water quality and can be controlled.

1.2 Need for a User's Manual

Sediment data users have expressed a strong desire for a more integrated approach to data collection in the province. The desire is for an approach that would not only coordinate ongoing monitoring programs, but would also develop linkages with special projects. Such an approach would lead to:

- an integrated network of water quantity/water quality, sediment quantity/sediment quality stations;
- an integrated and standardized approach to sampling water and sediment, quantity and quality, in time and space;
- an integrated and standardized approach to the analysis of water and sediment data samples; and
- an integrated and centralized data bank of information.

To achieve such integration and standardization, it is important to develop user-oriented handbooks regarding types of information available, methods of sediment data collection and analysis, and suggestions regarding data interpretation and use. This user's manual is offered as a step in this direction.

2.0 The Ontario Sediment Data Base

This chapter describes the availability of sediment data in Ontario. A Question and Answer format has been adopted for presentation. The following five questions are posed:

* Where are the Data?
* What Data are Available?
* How Do I Find the Data?
* How are the Tables and Reference Index Used?
* What are the Methods of Data Collection and Analysis Used?

* The answer to the first question outlines the publications containing sediment related data. Publications are restricted to those made available by the Sediment Survey Section of the Water Resources Branch.

* The second answer outlines the main types of data made available.

* The third answer outlines a procedure for finding sediment-related data for Ontario streams. The key tools utilized are: (1) a list of every location at which any category of sediment-related data has been obtained, and the number of years for which each category of data has been published; (2) the *Sediment Data Reference Index Canada* and; (3) a list of the various forms (eg historical, mean daily, or instantaneous concentration data), and the various publications in which the data can be found.

* The fourth answer is an example of how to use the tools presented in answer three.

* The fifth answer is a brief discussion of the methods used to collect, refine, and publish sediment-related data.

Note: The Tables outlined in answer three are presented following answer five. The tables presented are:

Table 2.1 Record and Data Availability for Ontario
Table 2.2 Index of Sediment Stations by Station Number
Table 2.3 Bibliographic Listing by Data Type
Table 2.4 Tabulation Listing by Publication

2.1 Where are the Data?

Sediment data collected by the Sediment Survey Section of the Water Resources Branch have been reported in various publications since the Ontario Sediment Survey Program began, in 1963. The first publication was an annual, entitled *Sediment Data Canadian Rivers*, which reported data from all continuous and seasonal stations in Canada. In 1971, *Sediment Data Canadian Rivers* underwent a major change in format, and in 1978 the International System (SI) of measurement units was adopted.

Since 1984, sediment data have been published in a new regional format. The publications are identified by province or territory and year (for example *Sediment Data - Ontario 1984*). All stations operated during the publication year (continuous, seasonal, and miscellaneous) are included. The format was expanded to include an historical summary. Before the introduction of the *Sediment Data* series, historical data summaries were published in a series entitled *Historical Sediment Data Summary for Canadian Rivers*.

Data collected from stations in the miscellaneous operation program were first published in *Miscellaneous Sediment Data 1966 to 1983*. This publication was a one-time publication for stations in Canada where miscellaneous data had been collected, but not previously published. Miscellaneous data is now published in the *Sediment Data* series on an annual basis.

Finally, the WRB publishes the *Sediment Data Reference Index Canada* biennially. The Reference Index provides a complete list of Canadian sediment stations, with a comprehensive tabulation of the data collected for each year of the station's operation.

2.2 What Data are Available?

Sediment and related data made available by the Sediment Survey Section of the Water Resources Branch fall into two main categories: 1) data obtained by direct sampling and laboratory analysis and 2) data derived from sampled data.

Data obtained by direct sampling and laboratory analysis include:

1) instantaneous suspended sediment concentration
2) dissolved solids concentration
3) suspended sediment particle size analysis
4) bed material particle size analysis
5) water temperature
6) bedload particle size analysis
7) bedload

The data obtained by sampling and laboratory analysis is related to the instantaneous discharge at the time of sampling. The discharge at the time of sampling is published with the sample data. The methods of collection and analysis pertaining to the above data are outlined in section 2.5 of this report.

Data derived from sample data include:

1) daily mean suspended sediment concentration
2) suspended sediment load
3) bed load

The derivation of the above data is limited to stations with a continuous or seasonal classification due to required inputs. The methodologies used for deriving the above data are outlined in section 2.5 of this manual.

2.3 How Do I Find The Data?

The key to locating Sediment Survey data is the publication *Sediment Data Reference Index Canada*. This publication lists each station that has been operated by Sediment Survey along with a complete tabulation of the data available for each station. The tabulation includes years of operation, type of operation, number of years for which a specific type of data is available and the total number of samples obtained for each data type. Information regarding the location of the station, stream flow type, and drainage basin size is also included.

An example of the tabulation is presented in figure 2.1 and is an excerpt of the most recently published edition of *Sediment Data Reference Index Canada* which was released in 1988. Stations are listed alphabetically by name. Station identification numbers are also listed. The station name and identification number correspond with flow station names and numbers where the two stations are coincident. In addition to the station name and number, location information, drainage basin size and streamflow regulation are listed.

Stations are assigned an operation type according to the collection program they are operated under for the year. Three operation types are possible: continuous, seasonal and miscellaneous. The operation type and mode of collection are listed together and are indicated by use of a letter. The key for the letters used is at the base of the table.

The period of record is broken into periods of homogeneous operation type. Each line of the station listing represents a specific period of homogeneous operation. Data made available for the period of operation are listed in the remaining columns. The column headings correspond to specific data types collected or derived that are made available. If data of a specific type is available during an operation period, the year(s) in which they were obtained are listed on the corresponding line.

ONTARIO

STATION NO.	NAME	TYPE OF OPERATION	SUSPENDED SEDIMENT						BED LOAD		BED MATERIAL PARTICLE SIZE
			CONC. DATA	LOADS	DISS. SOLIDS	WATER TEMP.	PARTICLE SIZE POINT	PARTICLE SIZE DEPTH	VOLUME OR LOADS	PARTICLE SIZE	
04ME003	ABITIBI RIVER AT OMAKAWAMA	M - MS M - MS	1978 1983		1984-88	1984-88					
	LATITUDE 50 36 00 N LONGITUDE 81 25 00 W DRAINAGE AREA 27 500 km²	M - MS	1984-88								
	TOTAL NUMBER OF SAMPLES		11		7	5					
	REMARK(S) - REGULATED										
04OD001	ALBANY RIVER ABOVE NOTTIK ISLAND	M - MS	1983								
	LATITUDE 51 38 30 N LONGITUDE 86 23 30 W DRAINAGE AREA 32 400 km²										
	TOTAL NUMBER OF SAMPLES		2								
	REMARK(S) - REGULATED										
04JA001	ALBANY RIVER NEAR HAT ISLAND	M - MS M - MS	1975-79 1980-81		1975-77	1980					
	LATITUDE 51 19 30 N LONGITUDE 85 52 20 W DRAINAGE AREA 118 000 km²	M - MS M - MS M - MS	1982-83 1983 1987		1983 1987	1982-83 1983 1987					
	TOTAL NUMBER OF SAMPLES		29		12	14					
	REMARK(S) - REGULATED SINCE 1934										
04DB001	ASHEWEG RIVER AT STRAIGHT LAKE	M - MS	1983								
	LATITUDE 53 43 00 N LONGITUDE 87 56 40 W DRAINAGE AREA 7 950 km²										
	TOTAL NUMBER OF SAMPLES		2								
	REMARK(S) - NATURAL FLOW										
04PC001	ATTAWAPISKAT RIVER BELOW MUKETEI RIVER	M - MS M - MS M - MS	1975-77 1980-81 1982-83		1975-77	1980 1982-83					
	LATITUDE 53 05 30 N LONGITUDE 85 00 30 W DRAINAGE AREA 36 000 km²	M - MS	1983-88		1983-88	1983-88					
	TOTAL NUMBER OF SAMPLES		28		14	12					
	REMARK(S) - NATURAL FLOW										
02FP002	AUSABLE RIVER NEAR SPRINGBANK	M - C M - C M - C M - S	1970-72 1973-76 1977-87 1988	1970-72 1973-76 1977-87 1988	1970-72 1973-76 1977-87 1988	1970-72 1973-76 1977-87 1988		1970 1973-76 1977-84			1973 1977-80
	LATITUDE 43 04 20 N LONGITUDE 81 39 33 W DRAINAGE AREA 840 km²										
	TOTAL NUMBER OF SAMPLES		1941		988	1699		98			32
	REMARK(S) - NATURAL FLOW										

Figure 2.1 Excerpt from the Sediment Data Reference Index

From the illustration (Figure 2.1) the Abitibi River at Onakawana has suspended sediment concentration data available for the years 1978, 1983 and 1986 - 1988. The station was operated as miscellaneous for each of the years indicated. The table also indicates dissolved solids concentration data and water temperature data are available for the years 1986 - 1988. For each data type the total number of samples is listed, eleven for suspended sediment concentrations, seven for dissolved solids concentrations and three for water temperature.

As an overview of data available for Ontario streams a condensed version of the reference index is made available in this report (Table 2.1). The table of Record and Data Availability for Ontario (Table 2.1) does not include a listing of particle size analysis by point integration method or bed load data since their relevancy to Ontario conditions is minimal. The table also excludes information concerning the location of the gauge, basin size, streamflow type and the number of samples per data type.

The table of Record and Data Availability for Ontario (Table 2.1) indicates the number of years for which a specific data type is available and is current to the end of 1990. Available data are divided into the same categories used in the reference index. There is no division of the data record by operation type although an indication of years of a specific operation type is given. Stations are listed in alphabetical order with station numbers. A listing of stations indexed by number is available in Table 2.2.

To illustrate the interpretation of the table an excerpt of the table is presented in Figure 2.2. From the illustration the Abitibi River at Onakawana has seven years of miscellaneous operation. The last year for which sediment data was obtained was 1990. Suspended sediment concentration data are available for six years, dissolved solids data for four years and water temperature data for four years. The listing is completed by indicating thirty one years of flow data available for this station.

Record and Data Availability for Ontario

STATION NAME AND NUMBER	TYPE OF OPERATION (C/S/M)	LAST YEAR LISTED	SUSPENDED SEDIMENT CONC.	DISSOLVED SOLIDS	WATER TEMPER-ATURE	SUSPENDED SEDIMENT PARTICLE-SIZE	BED MATERIAL PARTICLE-SIZE	SUSPENDED SEDIMENT LOAD	WATER FLOW DATA
ABITIBI RIVER AT ONAKAWANA 04MF001	0/0/7	1990	6	4	4	0	0	0	31
ALBANY RIVER ABOVE NOTTIK ISLAND 04D001	0/0/1	1983	1	1	0	0	0	0	24

Figure 2.2 Excerpt from Table 2.1
Note: Numbers in Figure 2.2 indicate number of years data is available, not number of samples obtained.

Sediment and related data are made available in a variety of forms. Each data category listed in Table 2.1 or the reference index represents a broad collection of forms in which the specific data are presented. As an example of the various data forms available for a specific data category let us look at the category suspended sediment concentration. Within this data category three main data forms are made available; historical summaries of extreme and mean values for a specified period, daily mean values associated with a specific day, and instantaneous values associated with a specific sample. The form "historical summaries" is made up of two related data forms; extreme values for the whole period of record and monthly/annual summaries of daily mean values.

A specific data form may be presented in various published tables and several data forms may be included in any one specific published table. As an aid to locating data a Bibliographic Listing by Data Type (Table 2.3) is presented as a map between data categories, forms of presentation, publications and published tables. Table 2.3 is organized by data categories as presented in table 2.1 and the reference index. For each data category the available forms of data are listed. For each unique form of data an associated publication and table are listed.

The Bibliographic Listing uses the following form:

MAIN HEADING

A. Form of Data

1. Subform of Data

i. Publication Title [Applicable Year(s)]:

a) Tabulation Title
(Tabulation Identification Number);
Remarks

The **MAIN HEADINGS** correspond with the column headings used by the Table of Record and Data Availability and the *Sediment Data Reference Index Canada* publication.

The publications referenced in the listing are indicated by the following acronyms:

SDCR - Sediment Data Canadian Rivers
SD - Sediment Data (Region)
MSDC - Miscellaneous Sediment Data Canada
HSDS - Historical Sediment Data Summary for Canadian Rivers

Tabulation titles correspond to the tabulation headings used in the Method of Tabulation section of the publication indicated. The Method of Tabulation section is found in the beginning of each publication. This section provides an explanation of the procedures and data found in the publication. One thing to note is that the title used for the published table may vary slightly from the Method of Tabulation headings/titles.

The **MAIN HEADING** of Suspended Sediment Concentration Data identifies the data category represented. At the next level of the listing the three main data forms are listed: Historical Summary of Extremes and Mean Values, Daily Mean Values and Instantaneous Values. The data form "Historical Summary" is further divided at the next level of the listing into two subforms of the data: Extreme Values and Monthly/Annual Mean Values.

Each unique data form is attached to one or more publications where the data form is tabulated. The years applicable for the publication is listed with each publication. The published table where the data are presented is listed for each publication. For the form **Daily Mean Values**, three publications are listed. The publication *Sediment Data Canadian Rivers* is the first listing. This publication is applicable for the years 1963-1970. The publication's tabulation where the data form can be found is listed as Daily Discharge, Daily Suspended Sediment Concentration and Daily Suspended Sediment Discharge (SDCR63-70:3).

Each tabulation has been given an identification number for cross-referencing between tables in this manual. The tabulation number listed for the above tabulation is SDCR63-70:3. The identification number begins with the publication title acronym, followed by the years for which the publication is applicable and finally, a unique number for each tabulation in the publication.

A listing of the publications and associated tabulations is given in Table 2.4 Tabulation Listing by Publication. The tabulations are grouped by publication. Tabulations can be identified by tabulation number or tabulation title and publication name. An example of each tabulation format is included with the listing for illustration purposes.

The following excerpt from the Bibliographic listing is presented for illustration purposes:

BIBLIOGRAPHIC LISTING: Suspended Sediment Concentration Data

A. Historical Summary of Extremes and Mean Values

1. Extremes Values
   a. HSDS (1963-1978):
      i.) Annual Extremes of Suspended Sediment and Load (HSDS63-78:2)
      ii.) Extremes Recorded for the Period of Record (HSDS63-78:2)
   b. SD (1963-): Historical Sediment Data Summary (SD84-:4)

2. Monthly and Annual Mean Values
   a. SDCR (1963-1970):
      i.) Daily Discharge, Daily Suspended Sediment Concentration and Daily Suspended Sediment Discharge (SDCR63-70:2)
      ii.) Summary of Total Discharge, Total Suspended Load and Mean Concentration (SDCR63-70:2)
   b. SDCR (1971-1983):
      i.) Daily Suspended Sediment Yield (SDCR71-83:1)
      ii.) Summary of Monthly and Annual Data (SDCR71-83:1)

B. Daily Mean

a. SDCR (1963-1970): Daily Discharge, Daily Suspended Sediment Concentration and Daily Suspended Sediment Discharge (SDCR63-70:2)

b. SDCR (1971-1983): Daily Suspended Sediment Yield (SDCR71-83:1)

c. SD (1984-): Suspended Sediment Load (SD84-:1)

C. Instantaneous

a. SDCR (1963-1970): Particle-size Analysis of Suspended Sediment (SDCR63-70:5)

b. SDCR (1971-1983): Particle-size Analysis of Suspended Sediment (SDCR71-83:3)

c. SD (1984-): Instantaneous Suspended Sediment Concentrations (SD84-:2)

d. MSDC (1966-1983): Instantaneous Suspended Sediment Concentrations (MSDC66-83:1)

Figure 2.3 Excerpt from Table 2.3 Bibliographic Listing

2.4 How are the Tables and Reference Index Used?

To help clarify the use of the tables and Reference Index the following example is presented:

Problem: Suppose one wishes to determine the availability of Daily Mean Concentration Data for the Ausable River Near Springbank. The particular years of record and the appropriate publications covering the period of record are required.

Solution: The Table of Record and Data Availability indicates that 20 years of Suspended Sediment Concentration Data exists (see Table 2.1). The 21 year record was current as of 1990.

To identify the specific years for which a record is available the *Sediment Data Reference Index* must be used. Because the *SDRI* is published every four years the most recently released version is current to the end of 1988. The *SDRI* indicates under the main heading of Suspended Sediment Concentration that data is available from 1970 - 1988 (see Figure 2.1). The Index breaks the period of record into homogenous operation periods. Data obtained in the years 1989 and 1990 while not yet tabulated in a *SDRI* are available from WRB.

As an aid to identifying appropriate publications and tabulations where the data may be found, Table 2.3, Bibliographic Listing is used. The Bibliographic Listing uses a hierarchical format to map the Main Headings used in the Reference Index and Table 2.1 Data Availability to available forms the data are published in and the specific publications and tabulations used for publication. Under the main heading Suspended Sediment Concentration, three subheadings are listed (see Figure 2.3). Daily Mean Values is the second subheading.

The publications and specific tabulations listed for Daily Mean Values are:

B. Daily Mean

a. SDCR (1963-1970): Daily Discharge, Daily Suspended Sediment Concentration and Daily Suspended Sediment Discharge (SDCR63-70:3)

b. SDCR (1971-1983): Daily Suspended Sediment Yield (SDCR71-83:1)

c. SD (1984-): Suspended Sediment Load (SD84-:1)

Therefore, Daily Mean Values of Suspended Sediment Concentration Data for the Ausable River Near Springbank are available in two tables of the SDCR publication series between 1970 and 1983, and one table in the SD publication series between 1984 and 1989.

If you wish to check the format of data presentation in the various tabulations a listing of tabulations with illustrations is presented in Table 2.4 of this manual.

2.5 What are the Methods of Data Collection and Analysis Used?

A brief overview of the methods used by the Sediment Survey Section of the Water Resources Branch to collect, analyze, and publish sediment-related information in Ontario is presented in this section.

Three introductory points are worth noting. First, the total sediment load can be subdivided into bed-load, which travels on or near the streambed, and suspended load, which travels in suspension in the flow. In Ontario, bed-load transport generally represents an insignificant fraction of the total load. Therefore, the collection and reporting of load information is focused on the suspended load.

Second, the Sediment Survey Section designates three types of stations: "continuous", "seasonal", and "miscellaneous". All categories of data can be obtained at each type of station, with one important exception: sediment loads can only be computed for continuous and seasonal stations equipped with a continuous water level recorder. Used with a stage-discharge (rating) curve, the water level record provides a continuous record of discharge at the station. The discharge record is used in the calculation of the mean daily concentrations and sediment loads.

Third, the concentration sampling frequency depends on station type. The sediment load calculation procedure requires a relatively intensive concentration sampling strategy. Samples are obtained as frequently as daily during periods of high flow and high sediment loads, and much less frequently during low flow periods, when concentrations and loads are low and relatively steady. For stations at which sediment loads are not computed, the sampling strategy is more regular but generally less frequent than for the sediment load stations.

The general procedure for collecting, analyzing, and publishing sediment data is outlined in Figure 2.4. Concentration samples are usually obtained by the depth-integrating method, whereby a sampler fills as it is lowered to the stream bed and raised back to the water surface, at a constant rate. Usually a single location (vertical) in the stream cross-section is sampled, but occasionally several verticals are sampled to ensure that the single vertical samples accurately represent cross-sectional average conditions. Several different samplers can be used, depending on flow conditions. The various samplers are outlined in the introductory pages of the annual *Sediment Data - Ontario* series.

Usually, water temperature and discharge are also measured, and bed material may be sampled to determine its particle size distribution. The concentration samples are analyzed in the laboratory to determine the concentrations of suspended sediment and dissolved solids, and the particle size distribution of the suspended sediment. Bed material samples are also analyzed in the laboratory. Procedures for these analyses are given in the manual: Laboratory Procedures for Sediment Analysis, Water Resources Branch, (1988(a)).

If the station is classified as miscellaneous sampling only the data are assembled annually and the tables outlined in Table 2.4 for the *Sediment Data - Ontario* publication are produced.

If sediment loads can be computed, an extra series of steps is undertaken. As a first step, the continuous water level chart is retrieved from the station. The measured concentrations for this period are plotted on the chart, and a smooth interpolating curve is drawn through them. The "concentration graph" thus constructed is then analyzed (using a digitizer) to calculate mean daily concentration values. The water level record is also digitized and used to calculate mean daily water levels and discharges. Daily suspended sediment load is then computed for each day by:

$$Q_s = 0.0864\ Q \cdot C \qquad \ldots\ldots (2.1)$$

where: Q_s = daily suspended sediment load (tonnes/day)
Q = mean daily discharge (m^3/s)
C = mean daily suspended sediment concentration (mg/L)
0.0864 = factor required for consistency of measurement units

These procedures are outlined in detail in the manual: Office Procedures for Sediment Data Computations, Water Resources Branch, (1988(b)). The concentration and load data are assembled annually, and used to produce the table of Suspended Sediment Load for the *Sediment Data - Ontario* publication.

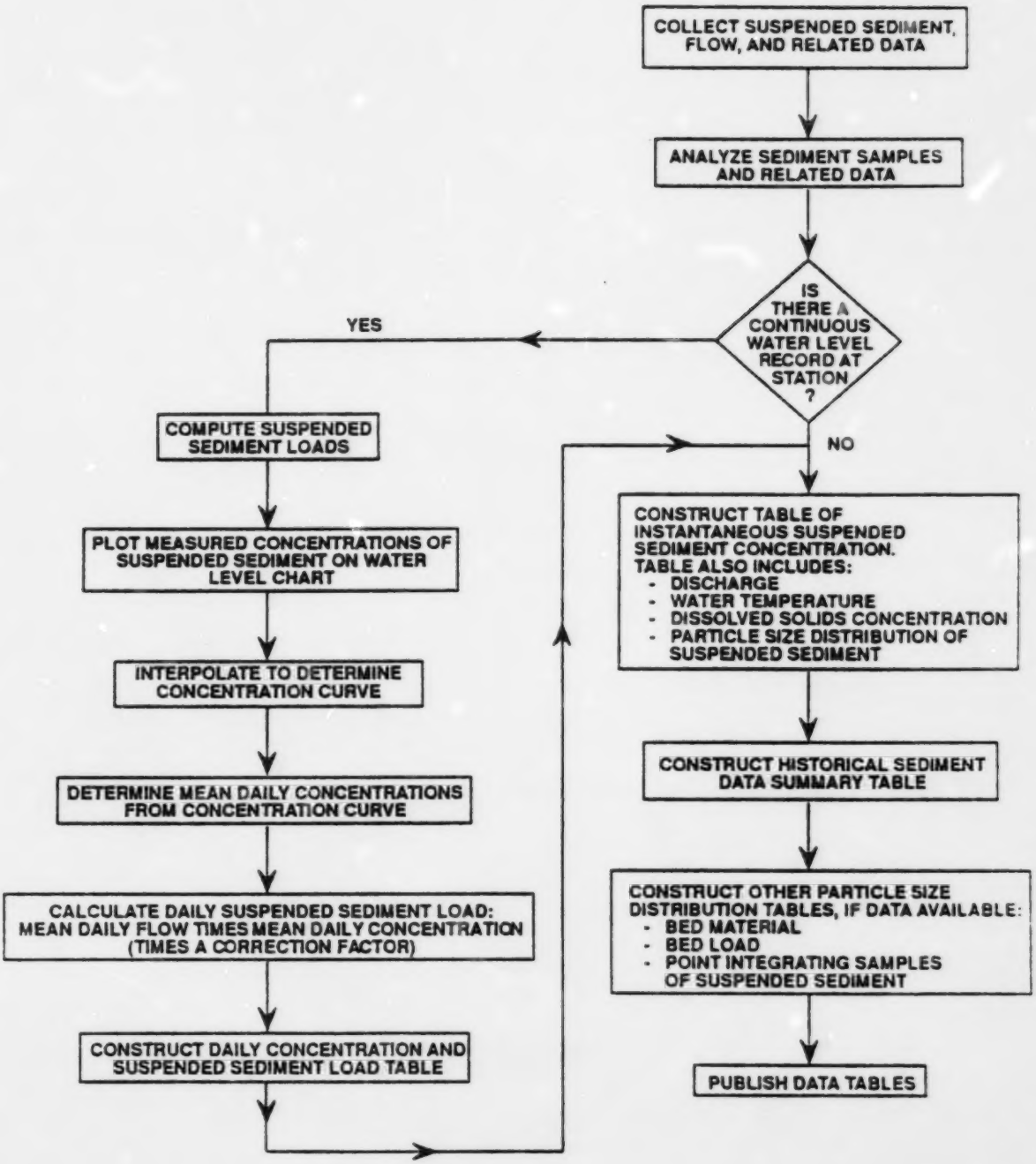
COLLECT SUSPENDED SEDIMENT, FLOW, AND RELATED DATA
ANALYZE SEDIMENT SAMPLES AND RELATED DATA
IS THERE A CONTINUOUS WATER LEVEL RECORD AT STATION ?
YES
NO
COMPUTE SUSPENDED SEDIMENT LOADS
PLOT MEASURED CONCENTRATIONS OF SUSPENDED SEDIMENT ON WATER LEVEL CHART
INTERPOLATE TO DETERMINE CONCENTRATION CURVE
DETERMINE MEAN DAILY CONCENTRATIONS FROM CONCENTRATION CURVE
CALCULATE DAILY SUSPENDED SEDIMENT LOAD: MEAN DAILY FLOW TIMES MEAN DAILY CONCENTRATION (TIMES A CORRECTION FACTOR)
CONSTRUCT DAILY CONCENTRATION AND SUSPENDED SEDIMENT LOAD TABLE
CONSTRUCT TABLE OF INSTANTANEOUS SUSPENDED SEDIMENT CONCENTRATION. TABLE ALSO INCLUDES:
- DISCHARGE
- WATER TEMPERATURE
- DISSOLVED SOLIDS CONCENTRATION
- PARTICLE SIZE DISTRIBUTION OF SUSPENDED SEDIMENT
CONSTRUCT HISTORICAL SEDIMENT DATA SUMMARY TABLE
CONSTRUCT OTHER PARTICLE SIZE DISTRIBUTION TABLES, IF DATA AVAILABLE:
- BED MATERIAL
- BED LOAD
- POINT INTEGRATING SAMPLES OF SUSPENDED SEDIMENT
PUBLISH DATA TABLES

Figure 2.4 Sediment Computation Flow Chart

Table 2.1 Record and Data availabilty for Ontario

STATION NUMBER AND NAME	TYPE OF OPERATION (C/S/M)	LAST YEAR LISTED	SUSPENDED SEDIMENT CONC.	DISSOLVED SOLIDS	WATER TEMPER-ATURE	SUSPENDED SEDIMENT PARTICLE SIZE	BED MATERIAL PARTICLE SIZE	SUSPENDED SEDIMENT LOAD	WATER FLOW DATA
ABITIBI RIVER AT ONAKAWANA 04ME003	0/0/7	1990	6	4	4	0	0	0	31
ALBANY RIVER ABOVE NOTTIK ISLAND 04GD001	0/0/1	1983	1	1	0	0	0	0	24
ALBANY RIVER NEAR HAT ISLAND 04HA001	0/0/11	1990	11	5	6	0	0	0	26
ASHEWEIG RIVER AT STRAIGHT LAKE: 04DB001	0/0/1	1983	1	0	0	0	0	0	24
ATTAWAPISKAT RIVER BELOW MUKETEI RIVER: 04FC001	0/0/13	1990	13	8	9	0	0	0	25
AUSABLE RIVER NEAR SPRINGBANK: 02FF002	19/2/0	1990	21	20	20	13	5	21	45
AUX SABLES RIVER AT MASSEY 02CE002	0/0/1	1990	1	1	1	0	0	0	75
BAILEY CREEK NEAR BEETON 02ED004	0/0/1	1978	1	1	1	0	0	0	17
BATCHAWANA RIVER NEAR BATCHAWANA 02BF001	0/0/2	1990	2	1	2	0	0	0	23
BAYFIELD RIVER NEAR VARNA 02FF007	0/0/5	1990	5	4	4	0	0	0	24
BEAR BROOK NEAR BOURGET 02LB008	0/0/1	1978	1	1	1	0	0	0	33
BEAVER RIVER NEAR CLARKSBURG: 02FF009	0/0/4	1990	4	4	4	0	0	0	33
BEAR CREEK BELOW BRIGDEN 02GG009	0/0/5	1990	5	5	5	1	0	0	9
BIG CARP RIVER NEAR SAULT STE. MARIE: 02BF004	0/0/1	1990	1	1	1	0	0	0	11
BIG CREEK NEAR WALSINGHAM 02GC007	20/1/2	1990	21	20	22	15	7	21	35
BIG OTTER CREEK NEAR CALTON 02GC026	14/2/0	1990	16	16	16	11	3	15	15
BIG OTTER CREEK NEAR VIENNA 02GC004	9/1/0	1975	10	10	10	10	4	10	34
BIGHEAD RIVER NEAR MEAFORD 02FB010	0/0/4	1990	4	4	4	0	0	0	33
BLACK ASH CREEK AT COLLINGWOOD: 02ED025	0/0/2	1990	2	2	2	0	0	0	2
BLACK CREEK NEAR WESTON 02HC027	0/0/1	1990	1	1	1	0	0	0	24

Note: Numbers in Table 2.1 refer to number of years in which samples were taken, not the number of samples taken.

STATION NUMBER AND NAME	TYPE OF OPERATION (C/S/M)	LAST YEAR LISTED	SUSPENDED SEDIMENT CONC.	DISSOLVED SOLIDS	WATER TEMPER-ATURE	SUSPENDED SEDIMENT PARTICLE SIZE	BED MATERIAL PARTICLE SIZE	SUSPENDED SEDIMENT LOAD	WATER FLOW DATA
BLACK RIVER NEAR MARATHON 02BB002	0/0/6	1990	6	6	6	0	0	0	23
BLACK STURGEON RIVER AT HIGHWAY #17: 02AC002	0/0/2	1990	2	2	2	0	0	0	19
BLOOMFIELD CREEK AT BLOOMFIELD: 02HE001	0/0/1	1990	1	1	1	0	0	0	21
BOWMANVILLE CREEK AT BOWMANVILLE: 02HD006	0/0/1	1990	1	1	1	1	0	0	31
BROUGHAM CREEK AT BROUGHAM 02HC044	1/1/0	1976	2	2	3	1	1	2	5
BUELLS CREEK AT BROCKVILLE 02MB010	0/0/1	1990	1	1	1	0	0	0	1
BURNT RIVER NEAR BURNT RIVER 02HF003	0/0/1	1990	1	1	1	0	0	0	28
CANAGAGIGUE CREEK NEAR ELMIRA: 02GA023	6/1/1	1990	8	7	7	7	2	7	34
CANAGAGIGUE CREEK NEAR FLORADALE: 02GA036	11/0/0	1984	11	11	11	8	7	11	16
CANARD RIVER NEAR LUKERVILLE 02GH003	0/0/2	1990	2	2	2	1	0	0	14
CAT RIVER BELOW WESLEYAN LAKE: 04GA002	0/0/1	1983	1	0	0	0	0	0	20
CATFISH CREEK NEAR SPARTA 02GC018	0/0/6	1990	6	5	5	1	0	0	26
CHIPPEWA CREEK AT NORTH BAY 02DD014	0/0/1	1990	1	1	1	0	0	0	16
COLLINS CREEK NEAR KINGSTON 02HM005	0/0/1	1990	1	1	1	0	0	0	21
CONESTOGO RIVER ABOVE DRAYTON: 02GA039	0/0/4	1990	4	3	3	0	0	0	17
COPELAND CREEK NEAR PENETANGUISHENE: 02ED019	0/0/2	1990	1	1	1	1	0	0	2
CREDIT RIVER AT ERINDALE 02HB002	14/4/0	1990	18	18	18	12	4	16	45
CREDIT RIVER AT NORVAL 02HB025	0/0/2	1990	2	2	2	1	0	0	3
CROWE RIVER AT MARMORA 02HK003	0/0/1	1990	1	1	1	0	0	0	31
CURRENT RIVER AT STEPSTONE 02AB021	0/0/1	1990	1	1	1	0	0	0	1
DON RIVER AT TODMORDEN 02HC024	3/1/2	1990	6	6	6	2	1	4	28
DUFFINS CREEK AT AJAX 02HC049	0/0/1	1990	1	1	1	0	0	0	1

Note: Numbers in Table 2.1 refer to number of years in which samples were taken, not the number of samples taken.

STATION NUMBER AND NAME	TYPE OF OPERATION (C/S/M)	LAST YEAR LISTED	SUSPENDED SEDIMENT CONC.	DISSOLVED SOLIDS	WATER TEMPER-ATURE	SUSPENDED SEDIMENT PARTICLE SIZE	BED MATERIAL PARTICLE SIZE	SUSPENDED SEDIMENT LOAD	WATER FLOW DATA
DUFFINS CREEK AT PICKERING 02HC006	0/3/1	1989	4	4	4	1	0	0	45
EAST CANAGAGIGUE CREEK NEAR FLORADALE: 02GA035	11/0/0	1984	11	11	11	6	7	11	16
EAST OAKVILLE CREEK NEAR OMAGH: 02HB004	0/0/1	1990	1	1	1	0	0	0	1
EKWAN RIVER BELOW NORTH WASHAGAMI RIVER: 04EA001	0/0/2	1990	2	0	1	0	0	0	23
ETOBICOKE CREEK BELOW QUEEN ELIZABETH HIGHWAY: 02HC030	0/0/6	1990	6	6	6	0	0	0	26
FAIRCHILD CREEK NEAR BRANTFORD: 02GB007	0/0/6	1990	6	6	6	0	0	0	26
FAREWELL CREEK AT OSHAWA 02HD014	1/5/1	1990	6	6	6	5	4	6	8
FAWN RIVER BELOW BIG TROUT LAKE: 04CE002	0/0/1	1983	1	0	0	0	0	0	24
FRENCH RIVER AT DRY PINE BAY 02DD010	0/0/2	1990	2	1	2	0	0	0	29
GANARASKA RIVER ABOVE DALE 02HD012	0/0/6	1990	6	6	6	1	0	0	13
GOULAIS RIVER NEAR SEARCHMOUNT: 02BF002	0/0/5	1990	5	4	5	0	0	0	23
GRAND RIVER AT BRANTFORD 02GB001	0/0/3	1990	3	2	2	0	0	0	52
GRAND RIVER AT GALT 02GA003	0/0/1	1975	1	0	0	0	0	0	60
GRAND RIVER AT MARSVILLE 02GA014	0/0/1	1990	0	0	0	0	0	0	32
GRAVEL RIVER NEAR CAVERS 02AE001	0/0/6	1990	6	6	6	0	0	0	16
GRINDSTONE CREEK NEAR ALDERSHOT: 02HB012	0/0/2	1990	2	2	2	0	0	0	25
HALFWAY CREEK AT MOOSONEE 04KA002	5/1/0	1983	6	6	6	0	1	6	14
HARMONY CREEK AT OSHAWA 02HD013	2/4/1	1990	6	6	6	5	4	6	8
HIGHLAND CREEK NEAR WEST HILL: 02HC013	1/0/5	1990	6	6	6	2	0	1	34
HOG CREEK NEAR VICTORIA HARBOUR: 02ED017	0/0/2	1990	1	1	1	0	0	0	2
HOLLAND RIVER AT HOLLAND LANDING: 02EC009	0/0/2	1990	2	2	2	1	0	0	4
HUMBER RIVER AT ELDER MILLS 02HC025	24/1/0	1990	25	25	25	22	6	25	27

Note: Numbers in Table 2.1 refer to number of years in which samples were taken, not the number of samples taken.

STATION NUMBER AND NAME	TYPE OF OPERATION (C/S/M)	LAST YEAR LISTED	SUSPENDED SEDIMENT CONC.	DISSOLVED SOLIDS	WATER TEMPER-ATURE	SUSPENDED SEDIMENT PARTICLE SIZE	BED MATERIAL PARTICLE SIZE	SUSPENDED SEDIMENT LOAD	WATER FLOW DATA
HUMBER RIVER AT WESTON 02HC003	10/2/1	1990	12	12	12	12	3	12	45
KEMPTVILLE CREEK NEAR KEMPTVILLE: 02LA006	0/0/5	1990	5	5	5	0	0	0	21
KENOGAMI RIVER NEAR MAMMAMATTAWA: 04JG001	0/0/1	1983	1	0	0	0	0	0	24
KETTLE CREEK AT ST. THOMAS 02GC002	0/0/6	1990	6	6	6	1	0	0	33
KWATABOAHEGAN RIVER NEAR THE MOUTH: 04KA001	0/0/1	1983	1	0	0	0	0	0	23
LITTLE CURRENT RIVER AT PERCY LAKE: 04JF001	0/0/1	1983	1	0	0	0	0	0	22
LITTLE OTTER CREEK NEAR STRAFFORDVILLE: 02GC015	0/0/4	1990	4	4	4	1	0	0	26
LITTLE PIC RIVER NEAR COLDWELL: 02BA003	0/0/4	1990	4	4	4	0	0	0	18
LITTLE ROUGE CREEK NEAR LOCUST HILL: 02HC028	0/3/2	1990	5	5	5	0	0	0	27
LUCKNOW RIVER AT LUCKNOW 02FD002	2/1/2	1990	4	4	4	0	2	3	10
LYN CREEK NEAR LYN 02MB006	0/0/4	1990	4	4	4	0	0	0	20
LYNDE CREEK WHITBY 02HC018	0/0/5	1990	5	5	5	0	0	0	29
MACINTYRE RIVER ABOVE THUNDER BAY: 02AB020	0/0/1	1990	1	1	1	0	0	0	1
MAD RIVER BELOW AVENING 02ED015	0/0/3	1990	3	3	3	0	0	0	3
MAD RIVER NEAR GLENCAIRN 02ED005	0/0/1	1987	1	0	0	0	0	0	21
MAGPIE RIVER NEAR MICHIPICOTEN: 02BD003	0/0/2	1990	2	2	2	0	0	0	51
MAITLAND RIVER NEAR DONNYBROOK: 02FE004	5/0/0/	1974	5	5	5	1	0	5	43
MCGREGOR CREEK NEAR CHATHAM: 02GE007	0/1/5	1990	6	6	6	3	0	1	13
MCKENZIE CREEK NEAR CALEDONIA: 02GB010	0/0/2	1990	2	2	2	0	0	0	28
MICHELL CREEK BELOW CLAREMONT: 02HC045	1/2/0/	1976	3	3	3	1	1	3	10
MILLHAVEN CREEK NEAR MILLHAVEN: 02HB006	0/0/1	1990	1	1	1	0	0	0	20
MIMICO CREEK AT ISLINGTON 02HC033	0/0/1	1990	1	1	1	1	0	0	23

Note: Numbers in Table 2.1 refer to number of years in which samples were taken, not the number of samples taken.

STATION NUMBER AND NAME	TYPE OF OPERATION (C/S/M)	LAST YEAR LISTED	SUSPENDED SEDIMENT CONC.	DISSOLVED SOLIDS	WATER TEMPER-ATURE	SUSPENDED SEDIMENT PARTICLE SIZE	BED MATERIAL PARTICLE SIZE	SUSPENDED SEDIMENT LOAD	WATER FLOW DATA
MISSISSAGI RIVER AT MISSISSAGI CHUTE: 02CC008	0/0/4	1990	4	3	4	0	0	0	50
MISSISSIPPI RIVER AT APPLETON 02KF006	0/0/4	1990	4	4	4	0	0	0	72
MOIRA RIVER NEAR FOXBORO 02HL001	0/0/3	1990	3	3	3	0	0	0	75
MOON RIVER AT HIGHWAY #69 02EB001	0/0/1	1990	1	1	1	0	0	0	25
MOOSE RIVER ABOVE MOOSE RIVER: 04LG004	0/0/8	1990	8	6	8	0	0	0	8
MOOSE RIVER AT MOOSE RIVER 04LG002	0/0/7	1981	7	2	4	0	0	0	25
NANTICOKE CREEK AT NANTICOKE 02GC022	0/0/6	1990	5	5	5	0	0	0	21
NAPANEE RIVER AT CAMDEN EAST 02HM007	0/0/4	1990	4	4	4	0	0	0	16
NEEBING RIVER NEAR THUNDER BAY: 02AB008	0/0/2	1990	2	2	2	0	0	0	37
NITH RIVER NEAR CANNING 02GA010	0/0/5	1990	5	3	3	1	0	0	52
NOLIN CREEK AT SUDBURY 02CF009	0/0/1	1990	1	0	1	0	0	0	31
NORTH FRENCH RIVER NEAR THE MOUTH: 04MF001	0/0/2	1990	2	0	1	0	0	0	24
NORTH MAGNETAWAN RIVER ABOVE: PICKEREL LAKE: 02EA010	4/1/1	1990	5	5	5	0	1	5	22
NORTH THAMES RIVER NEAR THORNDALE: 02GD015	0/0/6	1990	5	5	5	0	0	0	37
NOTTAWASAGA RIVER NEAR BAXTER: 02ED003	3/3/4	1990	10	9	10	2	1	7	44
O.A.C. FARM GAUGE NO. 5 AT GUELPH: 02GA032	13/3/0	1984	16	16	16	14	7	16	20
OGOKI RIVER ABOVE WHITECLAY LAKE: 04GB004	0/0/1	1983	1	0	0	0	0	0	19
OSHAWA CREEK AT OSHAWA 02HD005	0/0/1	1990	1	1	1	0	0	0	31
OTTAWA RIVER AT BRITANNIA 02CF005	0/6/0	1976	6	5	2	0	0	1	75
OTTAWA RIVER AT CUMBERLAND 02LB010	0/3/0	1979	3	3	0	0	0	0	72
PARKHILL CREEK ABOVE PARKHILL RESERVOIR: 02FF008	0/0/5	1990	5	5	5	0	0	0	16
PETAWAWA RIVER NEAR PETAWAWA: 02KB001	0/0/1	1990	1	1	1	0	0	0	79

Note: Numbers in Table 2.1 refer to number of years in which samples were taken, not the number of samples taken.

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PIC RIVER NEAR MARATHON 02BB003	0/0/6	1990	6	6	6	1	0	0	20
PIGEON RIVER AT MIDDLE FALLS 02AA001	0/0/2	1990	2	2	2	0	0	0	69
PINE RIVER AT LURGAN 02FD001	0/0/4	1990	4	4	4	0	0	0	16
PINEIMUTA RIVER AT EYES LAKE 04FA003	0/0/1	1983	1	0	0	0	0	0	24
PIPESTONE RIVER AT KARL LAKE 04DA001	0/0/1	1983	1	0	0	0	0	0	24
PUKASKA RIVER AT PUKASKA 02BC005	0/0/1	1990	1	1	1	0	0	0	1
RAISIN RIVER NEAR WILLIAMSTOWN: 02MC001	0/0/4	1990	4	4	4	0	0	0	30
REDHILL CREEK AT ALBION FALLS 02HA023	0/0/2	1990	2	2	2	0	0	0	3
REDHILL CREEK AT HAMILTON 02HA014	0/0/6	1990	5	5	5	1	0	0	13
REESOR CREEK ABOVE GREEN RIVER: 02HC039	1/2/0	1976	3	3	3	2	1	3	13
REESOR CREEK NEAR ALTONA 02HC040	1/2/0	1976	3	3	3	2	1	3	5
ROOT RIVER AT SAULT STE MARIE 02CA002	0/0/2	1990	2	1	2	0	0	0	19
ROSEBERRY RIVER ABOVE ROSEBERRY LAKES: 04CA003	0/0/5	1984	5	1	5	0	0	0	22
ROUGE RIVER AT SCARBOROUGH 02HC103	0/0/1	1975	1	1	1	0	0	0	4
ROUGE RIVER NEAR MARKHAM 02HC022	0/3/2	1990	5	5	5	2	0	0	29
RUSCOM RIVER NEAR RUSCOM STATION: 02GH002	0/0/5	1990	4	4	4	2	0	0	19
SACHIGO RIVER BELOW OUTLET OF SACHIGO LAKE: 04CD002	0/0/1	1983	1	0	0	0	0	0	20
SALMON RIVER NEAR SHANNONVILLE: 02HM003	0/0/5	1990	5	5	5	0	0	0	32
SAUGEEN RIVER NEAR PORT ELGIN 02FC001	2/3/3	1990	8	6	8	2	1	5	79
SERPENT RIVER AT HIGHWAY NO. 17: 02CD001	0/0/1	1990	1	0	1	0	0	0	24
SEVERN RIVER AT LIMESTONE RAPIDS: 04CC001	0/0/7	1990	6	4	6	0	0	0	20
SEVERN RIVER AT OUTLET OF MUSKRAT DAM LAKE: 04CA002	0/0/1	1983	1	0	0	0	0	0	25

Note: Numbers in Table 2.1 refer to number of years in which samples were taken, not the number of samples taken.

STATION NUMBER AND NAME	TYPE OF OPERATION (C/S/M)	LAST YEAR LISTED	SUSPENDED SEDIMENT CONC.	DISSOLVED SOLIDS	WATER TEMPER-ATURE	SUSPENDED SEDIMENT PARTICLE SIZE	BED MATERIAL PARTICLE SIZE	SUSPENDED SEDIMENT LOAD	WATER FLOW DATA
SEVERN RIVER BELOW OUTLET OF DEER LAKE: 04CA004	0/0/1	1983	1	0	0	0	0	0	19
SHAMATTAWA RIVER AT SHAMATTAWA LAKE: 04DC002	0/0/1	1990	1	0	1	0	0	0	24
SHELTER VALLEY BROOK NEAR GRAFTON: 02HD010	0/0/1	1990	1	1	1	1	0	0	25
SOUTH MAITLAND RIVER AT SUMMERHILL: 02FE009	1/3/3	1990	7	6	6	1	0	4	23
SOUTH NATION RIVER AT CASSELMAN: 02LB013	0/7/0	1982	7	4	7	0	0	7	18
SOUTH NATION RIVER AT CHESTERVILLE: 02LB009	0/0/1	1978	1	1	1	0	0	0	38
SOUTH NATION RIVER AT LEMIEUX 02LB015	0/11/0	1982	11	11	11	4	0	0	13
SOUTH NATION RIVER BELOW CASSELMAN: 02LB014	0/3/1	1975	4	4	2	0	0	0	13
SOUTH NATION RIVER NEAR PLANTAGENET SPRINGS: 02LB005	5/11/3	1990	19	17	19	3	1	16	80
SPEED RIVER NEAR ARMSTRONG MILLS: 02GA040	0/0/3	1990	3	2	2	0	0	0	17
SPENCER CREEK AT HIGHWAY NO.5: 02HB023	0/0/2	1990	2	2	2	0	0	0	4
STEEL RIVER NEAR TERRACE BAY 02BA002	0/0/2	1990	2	2	2	0	0	0	20
STOKES RIVER NEAR FERNDALE 02FA002	0/0/2	1990	2	2	2	0	0	0	14
STONEY CREEK AT STONEY CREEK 02HA022	0/0/2	1990	2	2	2	0	0	0	3
STOUFFVILLE CREEK BELOW STOUFVILLE: 02HC035	1/2/0	1976	3	3	3	1	1	3	10
STURGEON CREEK NEAR LEAMINGTON: 02GH001	5/1/1	1990	6	6	6	6	2	6	19
STURGEON RIVER AT STURGEON BAY: 02ED018	0/0/2	1990	2	2	2	0	0	0	3
SYDENHAM RIVER AT FLORENCE 02GC003	0/1/5	1990	6	6	6	1	0	2	7
SYDENHAM RIVER NEAR OWEN SOUND: 02FB007	0/0/4	1990	4	4	4	0	0	0	56
THAMES RIVER AT INGERSOLL 02GD016	10/1/1	1990	11	11	11	4	8	11	33
THAMES RIVER AT INNERKIP 02GD021	1/1/5	1990	7	7	7	0	0	2	12
THAMES RIVER AT THAMESVILLE 02GE003	3/1/2	1990	5	5	5	5	0	4	49

Note: Numbers in Table 2.1 refer to number of years in which samples were taken, not the number of samples taken.

STATION NUMBER AND NAME	TYPE OF OPERATION (C/S/M)	LAST YEAR LISTED	SUSPENDED SEDIMENT CONC.	DISSOLVED SOLIDS	WATER TEMPER-ATURE	SUSPENDED SEDIMENT PARTICLE SIZE	BED MATERIAL PARTICLE SIZE	SUSPENDED SEDIMENT LOAD	WATER FLOW DATA
TRENT RIVER AT GLEN ROSS 02HK004	0/0/4	1990	4	4	4	0	0	0	33
TURKEY CREEK AT WINDSOR 02GH004	0/0/1	1990	1	1	1	0	0	0	8
TWENTY MILE CREEK AT BALLS FALLS: 02HA006	0/0/4	1990	4	4	4	0	0	0	33
VERMILION RIVER NEAR VAL CARON: 02CF011	0/0/1	1990	1	0	1	0	0	0	20
WANAPITEI RIVER NEAR WANUP 02DB005	0/0/1	1967	1	1	1	0	0	0	38
WEST BRANCH LITLLE CATARAQUI CREEK AT KINGSTON: 02HM009	0/0/2	1990	2	2	2	0	0	0	3
WEST DUFFINS CREEK ABOVE GREEN RIVER: 02HC038	1/2/0	1990	3	3	3	2	1	3	11
WEST DUFFINS CREEK AT GREEN RIVER: 02HC026	1/2/1	1976	3	3	3	2	1	3	26
WEST DUFFINS CREEK NEAR ALTONA: 02HC041	1/2/0	1976	3	3	3	0	1	3	10
WEST DUFFINS CREEK NEAR PICKERING: 02HC106	0/4/0	1977	4	0	4	3	0	4	6
WEST HUMBER RIVER NEAR THISTLETOWN: 02HC008	0/1/1	1966	2	2	2	2	0	1	8
WHITEFISH RIVER AT NOLALU 02AB017	0/0/1	1990	1	1	1	0	0	0	8
WHITESAND CREEK NEAR SHRIEBER: 02BA005	0/0/2	1990	2	2	2	0	0	0	3
WILMOT CREEK NEAR NEWCASTLE 02HD009	0/0/1	1990	1	1	1	0	0	0	25
WILTON CREEK NEAR NAPANEE 02HM004	0/0/1	1990	1	1	1	0	0	0	25
WINDIGO RIVER ABOVE MUSKRAT DAM LAKE: 04CB001	0/0/1	1983	1	0	0	0	0	0	23
WINISK RIVER BELOW ASHEWEIG RIVER TRIBUTARY: 04DC001	0/0/9	1990	9	6	7	0	0	0	25
WIXON CREEK BELOW ALTONA 02HC046	1/2/0	1976	3	3	3	2	1	2	11
WOLF RIVER AT HIGHWAY NO. 17 02AC001	0/0/1	1990	1	1	1	0	0	0	19
WYE RIVER NEAR WYEVALE 02ED013	0/0/2	1990	2	2	2	0	0	0	2

Note: Numbers in Table 2.1 refer to number of years in which samples were taken, not the number of samples taken.

Table 2.2 INDEX OF SEDIMENT STATIONS BY STATION NUMBER

NUMBER	STATION NAME
02AA001	PIGEON RIVER AT MIDDLE FALLS
02AB008	NEEBING RIVER NEAR THUNDER BAY
02AB017	WHITEFISH RIVER AT NOLALU
02AB020	MCINTYRE RIVER AT THUNDER BAY
02AC001	WOLF RIVER AT HIGHWAY 17
02AC002	BLACK STURGEON RIVER AT HIGHWAY #17
02AC021	CURRENT RIVER AT STEPSTONE
02AE001	GRAVEL RIVER NEAR CAVERS
02BA002	STEEL RIVER NEAR TERRACE BAY
02BA003	LITTLE PIC RIVER NEAR COLDWELL
02BA005	WHITESAND CREEK NEAR SHRIEBER
02BB002	BLACK RIVER NEAR MARATHON
02BB003	PIC RIVER NEAR MARATHON
02BC004	WHITE RIVER BELOW WHITE LAKE
02BC005	PUKASKWA RIVER AT PUSKASKWA NATIONAL PARK
02BD003	MAGPIE RIVER NEAR MICUIPICOTEN
02BF001	BATCHAWANA RIVER NEAR BATCHAWANA
02BF002	GOULAIS RIVER NEAR SEARCHMONT
02BF004	BIG CARP RIVER NEAR SAULT STE.MARIE
02CA002	ROOT RIVER AT SAULT STE MARIE
02CC008	MISSISSAGI RIVER AT MISSISSAGI CHUTE
02CD001	SERPENT RIVER AT HIGHWAY 17
02CE002	AUX SABLES RIVER AT MASSEY
02CF009	NOLIN CREEK AT SUDBURY
02CF011	VERMILLION RIVER NEAR VAL CARRON
02DB005	WANAPITEI RIVER NEAR WANUP
02DD010	FRENCH RIVER AT DRY PINE BAY
02DD014	CHIPPEWA CREEK AT NORTH BAY
02EA010	NORTH MAGNETAWAN RIVER ABOVE PICKEREL LAKE
02EB001	MOON RIVER AT HIGHWAY 69
02EC009	HOLLAND RIVER AT HOLLAND LANDING
02ED003	NOTTAWASAGA RIVER NEAR BAXTER
02ED004	BAILEY CREEK NEAR BEETON
02ED005	MAD RIVER NEAR GLENCAIRN
02ED013	WYE RIVER NEAR WYEVALE
02EDO15	MAD RIVER BELOW AUEWING
02ED017	HOG CREEK NEAR VICTORIA HARBOUR
02ED018	STURGEON RIVER AT STURGEON BAY
02ED019	COPELAND CREEK NEAR PENETANGUISHENE
02ED025	BLACK ASH CREEK AT COLLINGWOOD
02FA002	STOKES RIVER NEAR FERNDALE
02FB009	BEAVER RIVER NEAR CLARKSBURG
02FB007	SYDENHAM RIVER NEAR OWEN SOUND
02FB010	BIGHEAD RIVER NEAR MEAFORD
02FC001	SAUGEEN RIVER NEAR PORT ELGIN

NUMBER	STATION NAME
02FD001	PINE RIVER AT LURGAN
02FD002	LUCKNOW RIVER AT LUCKNOW
02FE004	MAITLAND RIVER NEAR DONNYBROOK
02FE009	SOUTH MAITLAND RIVER AT SUMMERHILL
02FF002	AUSABLE RIVER NEAR SPRINGBANK
02FF007	BAYFIELD RIVER NEAR VARNA
02FF008	PARKHILL CREEK ABOVE PARKHILL RESERVOIR
02GA003	GRAND RIVER AT GALT
02GA010	NITH RIVER NEAR CANNING
02GA014	GRAND RIVER NEAR MARSVILLE
02GA023	CANAGAGIGUE CREEK NEAR ELMIRA
02GA032	O.A.C. FARM GAUAGE NO. 5 AT GUELPH
02GA035	EAST CANAGAGIGUE CREEK NEAR FLORADALE
02GA036	CANAGAGIGUE CREEK NEAR FLORADALE
02GA039	CONESTOGO RIVER ABOVE DRAYTON
02GB001	GRAND RIVER AT BRANTFORD
02GB007	FAIRCHILD CREEK NEAR BRANTFORD
02GB010	MCKENZIE CREEK NEAR CALEDONIA
02GC002	KETTLE CREEK AT ST. THOMAS
02GC004	BIG OTTER CREEK NEAR VIENNA
02GC007	BIG CREEK NEAR WALSINGHAM
02GC008	LYNN RIVER AT SIMCOE
02GC015	LITTLE OTTER CREEK NEAR STRAFFORDVILLE
02GC018	CATFISH CREEK NEAR SPARTA
02GC022	NANTICOKE CREEK AT NANTICOKE
02GC026	BIG OTTER CREEK NEAR CALTON
02GD015	NORTH THAMES RIVER NEAR THORNDALE
02GD016	THAMES RIVER AT INGERSOLL
02GD021	THAMES RIVER AT INNERKIP
02GE003	THAMES RIVER AT THAMESVILLE
02GE007	MCGREGOR CREEK NEAR CHATHAM
02GG003	SYDENHAM RIVER AT FLORENCE
02GG009	BEAR CREEK BELOW BRIGDEN
02GH001	STURGEON CREEK NEAR LEAMINGTON
02GH002	RUSCOM RIVER NEAR RUSCOM STATION
02GH003	CANARD RIVER NEAR LUKERVILLE
02GH004	TURKEY CREEK AT WINDSOR
02HA006	TWENTY MILE CREEK AT BALLS FALLS
02HA014	REDHILL CREEK AT HAMILTON
02HA022	STONEY CREEK AT STONEY CREEK
02HA023	REDHILL CREEK AT ALBION FALLS
02HB002	CREDIT RIVER AT ERINDALE
02HB004	EAST OAKVILLE CREEK NEAR OMAGH
02HB012	GRINDSTONE CREEK NEAR ALDERSHOT
02HB023	SPENCER CREEK AT HIGHWAY NO. 5
02HB025	CREDIT RIVER AT NORVAL
02HC003	HUMBER RIVER AT WESTON
02HC006	DUFFINS CREEK AT PICKERING
02HC008	WEST HUMBER RIVER NEAR THISTLETOWN
02HC013	HIGHLAND CREEK NEAR WEST HILL

NUMBER	STATION NAME
02HC018	LYNDE CREEK NEAR WHITBY
02HC022	ROUGE RIVER NEAR MARKHAM
02HC024	DON RIVER AT TODMORDEN
02HC025	HUMBER RIVER AT ELDER MILLS
02HC026	WEST DUFFINS CREEK AT GREEN RIVER
02HC027	BLACK CREEK AT WESTON
02HC028	LITTLE ROUGE CREEK NEAR LOCUST HILL
02HC030	ETOBICOKE CREEK BELOW QUEEN ELIZABETH HIGHWAY
02HC033	MIMICO CREEK AT ISLINGTON
02HC035	STOUFFVILLE CREEK BELOW STOUFFVILLE
02HC038	WEST DUFFINS CREEK ABOVE GREEN RIVER
02HC039	REESOR CREEK ABOVE GREEN RIVER
02HC040	REESOR CREEK NEAR ALTONA
02HC041	WEST DUFFINS CREEK NEAR ALTONA
02HC044	BROUGHAM CREEK AT BROUGHAM
02HC045	MITCHELL CREEK BELOW CLAREMONT
02HC046	WIXON CREEK BELOW ALTONA
02HC049	DUFFINS CREEK AT AJAX
02HC103	ROUGE RIVER AT SCARBOROUGH
02HC106	WEST DUFFINS CREEK NEAR PICKERING
02HD006	BOWMANVILLE CREEK AT BOWMANVILLE
02HD008	OSHAWA CREEK AT OSHAWA
02HD009	WILMOT CREEK NEAR NEWCSTLE
02HD010	SHELTER VALLEY BROOK NEAR GRAFTON
02HD012	GANARASKA RIVER ABOVE DALE
02HD013	HARMONY CREEK AT OSHAWA
02HD014	FAREWELL CREEK AT OSHAWA
02HE001	BLOOMFIELD CREEK AT BLOOMFIELD
02HE002	CONSECON CREEK AT ALLISONVILLE
02HF003	BURNT RIVER NEAR BURNT RIVER
02HK003	CROWE RIVER AT MARMORA
02HK004	TRENT RIVER AT GLEN ROSS
02HL001	MOIRA RIVER NEAR FOXBORO
02HM003	SALMON RIVER NEAR SHANNONVILLE
02HM004	WILTON CREEK NEAR NAPANEE
02HM005	COLLINS CREEK NEAR KINGSTON
02HM006	MILLHAVEN CREEK NEAR MILLHAVEN
02HM007	NAPANEE RIVER AT CAMDEN EAST
02HM009	WEST BRANCH LITTLE CATARAQUI CREEK AT KINGSTON
02KB001	PETAWAWA RIVER NEAR PETAWAWA
02KF005	OTTAWA RIVER AT BRITANNIA
02KF006	MISSISSIPPI RIVER AT APPLETON
02LA006	KEMPTVILLE CREEK NEAR KEMPTVILLE
02LB005	SOUTH NATION RIVER NEAR PLANTAGENET SPRINGS
02LB008	BEAR BROOK NEAR BOURGET
02LB009	SOUTH NATION RIVER AT CHESTERVILLE
02LB010	OTTAWA RIVER AT CUMBERLAND
02LB013	SOUTH NATION RIVER AT CASSELMAN
02LB014	SOUTH NATION RIVER BELOW CASSELMAN
02LB015	SOUTH NATION RIVER AT LEMIEUX

NUMBER	STATION NAME
02MB006	LYN CREEK NEAR LYN
02MB010	BUELLS CREEK AT BROCKVILLE
02MC001	RAISIN RIVER NEAR WILLIAMSTOWN
04CA002	SEVERN RIVER AT OUTLET OF MUSKRAT DAM LAKE
04CA003	ROSEBERRY RIVER ABOVE ROSEBERRY LAKES
04CA004	SEVERN RIVER BELOW OUTLET OF DEER LAKE
04CB001	WINDIGO RIVER ABOVE MUSKRAT DAM LAKE
04CC001	SEVERN RIVER AT LIMESTONE RAPIDS
04CD002	SACHIGO RIVER BELOW OUTLET OF SACHIGO LAKE
04CE002	FAWN RIVER BELOW BIG TROUT LAKE
04DA001	PIPESTONE RIVER AT KARL LAKE
04DB001	ASHEWEIG RIVER AT STRAIGHT LAKE
04DC001	WINISK RIVER BELOW ASHEWEIG RIVER TRIBUTARY
04DC002	SHAMATTAWA RIVER AT OUTLET SHAMATTAWA LAKE
04EA001	EKWAN RIVER BELOW NORTH WASHAGAMI RIVER
04FA003	PINEIMUTA RIVER AT EYES LAKE
04FC001	ATTAWAPISKAT RIVER BELOW MUKETEI RIVER
04GA002	CAT RIVER BELOW WESLEYAN LAKE
04GB004	OGOKI RIVER ABOVE WHITECLAY LAKE
04GD001	ALBANY RIVER ABOVE NOTTIK ISLAND
04HA001	ALBANY RIVER NEAR HAT ISLAND
04JF001	LITTLE CURRENT RIVER AT PERCY LAKE
04JG001	KENOGAMI RIVER NEAR MAMMAMATTAWA
04KA001	KWATABOAHEGAN RIVER NEAR THE MOUTH
04KA002	HALFWAY CREEK AT MOOSONEE
04LG002	MOOSE RIVER AT MOOSE RIVER
04LG004	MOOSE RIVER ABOVE MOOSE RIVER
04ME003	ABITIBI RIVER AT ONAKAWANA
04MF001	NORTH FRENCH RIVER NEAR THE MOUTH

Table 2.3 BIBLIOGRAPHIC LISTING

SUSPENDED SEDIMENT CONCENTRATION

A. Historical Summary of Extremes and Mean Values

1. Extremes Values

a. HSDS (1963-1978):

i.) Annual Extremes of Suspended Sediment and Load (HSDS63-78:2)
ii.) Extremes Recorded for the Period of Record (HSDS63-78:2)

b. SDCR (1963-1970): Extremes Recorded for the Period of Record (SDCR63-70:1)

c. SD (1984-): Historical Sediment Data Summary (SD84-:4)

2. Monthly and Annual Mean Values

a. SDCR (1963-1970):

i.) Daily Discharge, Daily Suspended Sediment Concentration and Daily Suspended Sediment Discharge (SDCR63-70:3)
ii.) Summary of Total Discharge, Total Suspended Load and Mean Concentration (SDCR63-70:3)

b. SDCR (1971-1983):

i.) Daily Suspended Sediment Yield (SDCR71-83:1)
ii.) Summary of Monthly and Annual Data (SDCR71-83:1)

B. Daily Mean

a. SDCR (1963-1970): Daily Discharge, Daily Suspended Sediment Concentration and Daily Suspended Sediment Discharge (SDCR63-70:3)

b. SDCR (1971-1983): Daily Suspended Sediment Yield (SDCR71-83:1)

c. SD (1984-): Suspended Sediment Load(SD84-:1)

C. Instantaneous

a. SDCR (1963-1970): Particle-size Analysis of Suspended Sediment (SDCR63-70:4)

b. SDCR (1971-1983): Particle-size Analysis of Suspended Sediment (SDCR71-83:3)

c. SD (1984-): Instantaneous Suspended Sediment Concentrations (SD84-:2)

d. MSDC (1966-1983): Instantaneous Suspended Sediment Concentrations (MSDC66-83:1)

DISSOLVED SOLIDS

a. SD (1984-): Instantaneous Suspended Sediment Concentration (SD84-:2)

b. MSDC (1966-1983): Instantaneous Suspended Sediment Concentration (MSDC66-83:1)

Remark: Dissolved Solids Data for continuous and seasonal operations are not published for years before 1984. This information is available upon request to Environment Canada, Water Resources Branch, Sediment Survey Section.

WATER TEMPERATURE

a. SDCR (1963-1970): Daily Discharge, Daily Suspended Sediment Concentration,and Daily Suspended Sediment Discharge (SDCR63-70:3)

b. SDCR (1971-1983): Daily Suspended Sediment Yield (SDCR71-83:1)

c. SD (1984-): Instantaneous Suspended Sediment Concentration (SD84-:2)

d. MSDC (1966-1983): Instantaneous Suspended Sediment Concentration (MSDC66-83:1)

BED LOAD

A. Historical Summary of Extremes and Mean Values

1. Monthly and Annual Mean Values

a. SDCR (1963-1970): Particle-size Analyses of Bed Load (SDCR63-70:7)

b. HSDS (1963-1978): Summary of the Monthly and Annual Total Volumetric Bed Load (HSDS63-78:4)

Remark: Original data for years not published is available upon request from Environment Canada, Water Resources Branch, Water Survey of Canada, Sediment Survey Section, Ottawa, Canada

PARTICLE-SIZE ANALYSIS

A. Suspended Sediment

a. SDCR (1963-1970): Particle-size Analysis of Suspended Sediment (SDCR63-70:4)

b. SDCR (1971-1983): Particle-size Analysis of Suspended Sediment (SDCR71-83:3)

c. SD (1984-):
   i.) Instantaneous Suspended Sediment Concentration (SD84-:2)
   ii.) Point Integration Particle-size of Suspended Sediment (SD84-:5)

d. MSDC (1966-1983): Instantaneous Suspended Sediment Concentration (MSDC66-83:1)
   i.) Suspended Particle-size Distribution; Graphical
   ii.) Suspended Particle-size Distribution Relationships; A Series of Graphical Presentations

B. Bed Load

a. SDCR (1963-1970): Particle-size Analysis of Bed Load (SDCR63-70:7)

b. SDCR (1971-1983): Particle-size Analysis of Bed Load (SDCR71-83:4)

c. SD (1984-): Bed Load Particle-size (SD84-:6)

d. MSDC (1966-1983): Bed Load Particle-size (MSDC66-83:3)

C. Bed Material

a. SDCR (1963-1970): Particle-size Analysis of Bed Material (SDCR63-70:5)

b. SD (1984-): Bed Material Particle-size (SD84-:3)

c. MSDC (1966-1983): Bed Material Particle-size Analysis (MSDC66-83:2)

SUSPENDED SEDIMENT LOAD

A. Historical Summary of Extremes and Mean Values

1. Extremes Values

a. SDCR (1963-1970): Extremes Recorded for the Period of Record (SDCR63-70:1)

b. SDCR (1971-1983): Summary of Monthly and Annual Data (SDCR71-83:1)

c. SD (1984-): Historical Sediment Data Summary (SD84-:4)

d. HSDS (1963-1978): Annual Extremes of Suspended Sediment Concentration and Load and Annual Total and Annual Mean Suspended Sediment Load (HSDS63-78:2)

2. Monthly and Annual Mean Values

a. SDCR (1963-1970): Monthly and Annual Mean Suspended Sediment Load (SDCR63-70:2)

b. SDCR (1971 - 1983): Summary of Monthly and Annual Data (SDCR71-83:1)

c. SD (1984-): Historical Sediment Data Summary (SD84-:4)

d. HSDS (1963-1978): Summary of Monthly Mean Suspended Sediment Load (HSDS63-78:1)

e. HSDS (1963-1978): Annual Maximum and Minimum Suspended Sediment and Annual Total Suspended Load and Annual Mean Load (HSDS63-78:2)

B. Daily Mean

a. SDCR (1963-1970): Daily Discharge, Daily Suspended Sediment Concentration and Daily Suspended Sediment Discharge (SDCR63-70:3)

b. SDCR (1971-1983): Daily Suspended Sediment Yield (SDCR71-83:1)

c. SD (1984-): Suspended Sediment Load (SD84-:1)

C. Monthly and Annual Mean Values

a. SDCR (1963-1970): Monthly and Annual Mean Suspended Sediment Load (SDCR63-70:2)

b. SDCR (1971-1983): Summary of Monthly and Annual Data (SDCR71-83:1)

c. SD (1984-): Suspended Sediment Load (SD84-:1)

FLOW DATA (Related to Sediment Data)

a. Surface Water Data (Region), Water Survey of Canada; Tabular presentation of discharge data.

ADDITIONAL REFERENCES

A. Station Analysis: These reports contain all the available sediment and related data for a particular station. They also contain some data analysis (specific to the station) and comments concerning the station and data.

The following two are currently available:

i.) Big Creek Near Walsingham

ii.) Humber River at Elder Mills

B. Sediment Survey Section Report Series: Water Resources Branch, Water Survey of Canada, Sediment Survey Section has produced several reports on various aspect of their program. Abstracts have been compiled in the following report:

i.) A Compilation of Sediment Survey Report Series Abstracts to 1988, M.A.Cashman.

Remark: The individual reports are available upon request from Environment Canada, Water Resources Branch, Water Survey of Canada, Sediment Survey Section, Ottawa, Canada.

TABLE 2.4 Tabulation Listing by Publication

Sediment Data Canadian Rivers (1963-1970) Environment Canada, Inland Waters Directorate, Water Resources Branch, Water Survey of Canada, Ottawa, Canada.

SDCR63-70:1 - The Extremes Recorded for the Period of Record lists the maximum and minimum suspended sediment load for the recording period.

SDCR63-70:2 - The table of Monthly and Annual Mean Suspended Sediment Load gives the average rate of suspended sediment discharge (tons) for each month and each year of record.

SDCR63-70:3 - The table of Daily Discharge, Daily Suspended Sediment Concentration, and Daily Suspended Sediment Discharge gives:

(a) daily discharge (cubic feet per second, cfs);
(b) daily mean suspended sediment concentration (milligrams per litre, mg/L);
(c) suspended sediment discharge (tons per day) at the station;
(d) water temperature during sampling (°C);
(e) for each month the following are shown at the bottom of the table:

(i) total discharge (cfs-days);
(ii) total suspended sediment load (tons);
(iii) sum of the daily suspended sediment concentrations (mg/L);
(iv) mean monthly values of discharge, suspended sediment concentration and suspended sediment discharge;

(f) A summary of total discharge, total suspended load and mean concentration for the year or period is given below the table.

SDCR63-70:4 - The table of Particle-size Analyses of Suspended Sediment gives:

(a) date and time of each sampling;
(b) discharge at time of sampling (cfs);
(c) water temperature during sampling (°C);
(d) concentration (mg/L);
(e) particle-size distribution.

SDCR63-70:5 - The table of Particle-size Analyses of Bed Material gives:

(a) date and time of each sampling;
(b) discharge at time of sampling (cfs);
(c) number of samples taken during each sampling;
(d) average particle-size distribution.

SDCR63-70:6 - The table of Bed Load gives total bed load discharge (cubic yards per month).

SDCR63-70:7 - The table of Particle-size Analyses of Bed Load gives the average particle-size distribution for the cross section.

Note: No bed load discharge or bed load particle size data are available for Ontario, except Harmony Creek near Oshawa, in 1982.

HUMBER RIVER AT ELDER MILLS - STATION No. 02HC025

Location: Lat. 43° 48' 39", long. 79° 37' 38", Ontario, on the right bank, downstream side of the township road bridge, about one-third mile east of Elder station at Elder Mills.
Drainage Area: 117 square miles.
Gauge: Recording.
Period of Record: Suspended sediment load, March 1966 to December 1969.
Extremes Recorded: Maximum daily suspended sediment load, 5,520 tons/day on April 3,1967.
Minimum daily suspended sediment load, 0.9 tons/day on May 11,1966.

SDCR63-70:1 Extremes Recorded for the Period of Record

Monthly Mean Suspended Sediment Load in Tons per Day

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Mean
1966			81.5	6.8	10.3	9.0	1.9	1.9	3.3	2.0	12.4	28.2	
1967	17.4	8.1	228	346	13.7	65.0	77.7	21.2	9.5	17.2	14.7	44.2	72.0
1968	6.1	91.5	478	38.9	13.8	12.9	7.1	54.4	6.6	4.2	44.8	21.9	65.3
1969	22.2	11.5	379	415	26.9	5.0	8.3	4.7	3.1	3.1	6.3	3.5	74.3

SDCR63-70:2 Monthly and Annual Mean Suspended Sediment Load

HUMBER RIVER AT ELDER MILLS (Cont.)
Suspended Sediment for 1969

Day	October				November				December			
	Water Temp. (°C)	Daily Discharge (cfs)	Suspended Sediment		Water Temp. (°C)	Daily Discharge (cfs)	Suspended Sediment		Water Temp. (°C)	Daily Discharge (cfs)	Suspended Sediment	
			Mean Conc. (mg/l)	Tons per Day			Mean Conc. (mg/l)	Tons per Day			Mean Conc. (mg/l)	Tons per Day
1		38.3	35	3.6		51.0	10	1.4		48.8B	33	4.3
2		39.3	35	3.7		105	48	13.6		48.2B	34	4.4
3		40.2	35	3.8	9.0	152	605	24.6	0.5	50.3B	355	4.8
4		39.5	34	3.6	8.5	97.8	425	11.1		71.3B	34	6.5
26		65.2	17	3.0		58.1B	29	4.5		49.4B	17	2.3
27		58.8	15	2.4		56.2B	30	4.6		49.6B	16	2.1
28		55.7	14	2.1		54.0B	31	4.5		49.4B	16	2.1
29		52.5	13	1.8		51.9B	32	4.5		49.0B	15	2.0
30		50.5	12	1.6		50.0B	33	4.5		49.9B	15	2.0
31	3.5	48.8	11S	1.4		-	-	-		50.0B	15	2.0
Total		1,499.1	760	96.7		2,231.0	792	188.6		1,646.1	738	107.4
Mean		48.4	25	3.1		74.4	26	6.3		53.1	24	3.5

The Year: Total discharge, 35,189.5 cfs-days
Total suspended load, 27,104.4 tons
Mean concentration, 285 mg/l

B - Ice conditions
S - Sample(s) collected this day.

SDCR63-70:3 Daily Discharge, Daily Suspended Sediment Concentration and Daily Suspended Sediment Discharge

Particle-size Analyses of Suspended Sediment

(Method of analysis; B, bottom withdrawal tube; P, pipette; S, sieve; N, in native water; W, in distilled water; C, chemically dispersed; M, mechanically dispersed; V, visual accumulation tube)

Date of Collection	Time	Discharge Measurement (cfs)	Water Temp. (°C)	Suspended Sediment										Methods of analysis
				Concentration of Sample(s) (mg/l)	Per cent finer than indicated size, in millimetres									
					0.002	0.004	0.008	0.016	0.031	0.062	0.125	0.250	0.500	1.000
1969					Depth Integrating									
March 19	1530	478H	0	565K	9	22	40	56	72	82	88	93	96	98	BNW
March 21	1700	972H	0	1,200K	13	24	39	56	68	80	88	93	96	100	"
March 22	1700	651H	0	591K	10	18	32	54	74	88	92	96	99	100	"
March 24	1100	491H	1.0	572K	5	12	29	51	71	88	97	99	100		"
March 25	1100	496	3.5	721R	8	14	26	45	62	80	93	98	100		"
March 25	1400	537H	1.5	717K	6	11	24	45	66	84	96	99	99	100	"
March 25	1430	534	1.5	739R	6	13	28	49	66	82	93	98	99	100	"
March 28	1500	206H	0	174K	9	19	41	65	80	89	94	97	99	100	"
April 2	1200	501H	0	553K	25	31	46	65	80	92	96	98	99	100	"
April 5	1500	803H	4.0	766K	9	15	30	46	67	83	96	99	99	100	"
April 18	1230	775H	4.5	2,780K	16	26	39	55	72	87	96	99	99	100	"
April 18	1500	775H	3.5	3,650R	11	17	28	44	63	81	93	98	99	100	"

H - Daily mean discharge. K - Sample(s) collected in single vertical. R - Sample(s) collected in several verticals.

SDCR63-70:4 **Particle-size Analyses of Suspended Sediment**

HUMBER RIVER AT ELDER MILLS (Con.)

Particle-size Analyses of Bed Material

(Methods of analysis: B, bottom withdrawal tube; P, pipette; S, sieve; N, in native water; W, in distilled water; C, chemically dispersed; M, mechanically dispersed; V, visual accumulation tube; H, hydrometer

Date	Time	Discharge Measurement (cfs)	Number of Sampling Points in Cross Section	Bed Material										Method of analysis	Remarks
				Per cent finer than indicated size (mm)											
				0.016	0.031	0.062	0.125	0.250	0.500	1.000	2.000	4.000	8.000	16.000	
1969 May 1	1350	156	7			9	19	30	39	45	50	56			S	LANE

SDCR63-70:5 **Particle-size Analyses of Bed Material**

Sediment Data Canadian Rivers (1971-1983) Environment Canada, Inland Waters Directorate, Water Resources Branch, Water Survey of Canada, Ottawa, Canada.

SDCR71-83:1 - The table of Daily Suspended Sediment Yield includes:

(a) daily mean discharge (m^3/s);
(b) daily mean concentration (mg/L);
(c) daily suspended sediment (tonnes per day);
(d) water temperature during sampling (^0C).

A Summary of Monthly and Annual Data follows the table, and includes:

(a) Monthly summary:

(i) total of the daily discharges, and mean daily discharge (m^3/s);
(ii) total of the daily sediment loads, and mean daily sediment load (tonnes per day).

(b) Summary for the full or partial year:

(i) maximum, minimum, and mean daily suspended sediment concentration (mg/L);
(ii) maximum, minimum, and mean daily load (tonnes per day);
(iii) total load (tonnes).

Notes:

Descriptive information about the station, including location, drainage area, flow type (natural or regulated), and gauge type is also given.

For stations where daily loads are calculated for complete years or standard periods, both the monthly and annual summaries are reported.

For stations where load data is not available for complete years or standard periods, annual data are not reported.

For stations where concentration data are obtained, but loads are not calculated, neither monthly nor annual data are reported.

SDCR71-83:3 - The table of Particle-size Analysis of Suspended Sediment for depth and point integrating samples includes:

(a) date and time of each sampling;
(b) discharge at time of sampling (m^3/s);
(c) water temperature during sampling (^0C);
(d) concentration (mg/L);
(e) particle-size distribution.

SDCR71-83:4 - The table of Particle-size Analysis of Bed Load includes:

(a) date and time of each sampling;
(b) discharge through sampling vertical (m^3/s);
(c) location of sampling vertical;
(d) type of sampler used;
(e) average cross-sectional bed load particle size distribution.

Note: Bed load data are available for only one station in Ontario, Harmony Creek near Oshawa, in 1982

Sediment Data Ontario (1984 - present) Environment Canada, Inland Waters Directorate, Water Resources Branch, Water Survey of Canada, Ottawa, Canada.

SD84-:1 - The table of Suspended Sediment Load includes:

(a) daily mean discharge (m^3/s);
(b) daily mean concentration (mg/L);
(c) daily load (tonnes per day);
(d) total discharge and sediment load for each month of record.

Notes: Descriptive information about the station, including location, drainage area, flow type (natural or regulated), and gauge type is also given.

The total load for the partial or complete year is given with the above descriptive information.

SD84-:2 - The table of Instantaneous Suspended Sediment Concentration for depth-integrating samples includes:

(a) date and time of each sampling;
(b) water temperature during sampling (^0C);
(c) discharge at time of sampling (if not available, the daily mean discharge is given and indicated by a symbol) (m^3/s);
(d) location of the sampling vertical;
(e) type of sampler used;
(f) suspended sediment concentration (mg/L);
(g) dissolved solids concentration (mg/L);
(h) particle-size distribution in percent finer than indicated size (mm);
(i) particle-size distribution in percent sand, silt, and clay.

SD84-:3 - The table of Bed Material Particle-size includes:

(a) date and time of each sampling;
(b) discharge through each sampling vertical (m^3/s);
(c) location of each sampling vertical;
(d) type of sampler used;
(e) particle-size distribution in percent finer than indicated size (mm).

SD84-:4 - The table of Historical Sediment Data Summary gives:

(a) list of the particular months of each year for which suspended sediment concentration data are available;
(b) sampling technique (manual, automatic, or both);
(c) maximum and minimum sampled concentration (mg/L) for each year, and date of collection;
(d) maximum daily suspended sediment load (tonnes) for each year, and date of occurrence;
(e) total load for each partial or full year (tonnes);
(f) summary of the mean daily load for each year, and the long-term average annual load (tonnes). The standard error of the historical mean is included.

Note: Loads are not computed for all stations. For stations without load data, this table includes only the concentration information.

SD84-:5 - The table of Point Integrating Particle-size of Suspended Sediment includes:

(a) date and time of each sampling;
(b) water temperature during sampling (°C);
(c) discharge through each sampling vertical (m^3/s);
(d) location of each sampling vertical;
(e) depth of sample;
(f) suspended sediment concentration of each sample (mg/L);
(g) dissolved solids concentration of each sample (mg/L);
(h) particle-size distribution in percent finer than indicated size (mm);
(i) particle-size distribution in percent sand, silt and clay.

Note: The two stations with any point-integrating particle-size record are:

Humber River w Wwton, in 1965
Thames River at Thamesville, in 1975

Therefore, this table has not been presented in the *Sediment Data - Ontario* series.

SD84-:6 - The table of Bed Load Particle-size includes:

(a) date and time of each sampling;
(b) discharge through each sampling vertical (m^3/s);
(c) location of each sampling vertical;
(d) type of sampler used;
(e) particle-size distribution of each sample, in percent finer than indicated size (mm).

Note: Bedload particle-size data is available for only one station in Ontario: Harmony Creek near Oshawa, in 1982. The data is available in Sediment Data Canadian Rivers.

Miscellaneous Sediment Data Canada (1966-1983) Environment Canada, Inland Waters Directorate, Water Resources Branch, Water Survey of Canada, Ottawa, Canada.

MSDC66-83:1 - The table of Instantaneous Suspended Sediment Concentration for depth-integrating samples includes:

(a) date and time of each sampling;

(b) water temperature during sampling (°C);
(c) discharge at time of sampling (if not available, the daily mean discharge is given and indicated by a symbol) (m^3/s);
(d) suspended sediment concentration (mg/L);
(e) dissolved solids concentration (mg/L);
(f) particle-size distribution in percent finer than indicated size (mm);
(g) particle-size distribution in percent sand, silt, and clay.

MSDC66-83:2 - The table of Bed Material Particle-Size Analysis gives:

(a) date and time of each sampling;
(b) discharge at time of sampling (m^3/s);
(c) nwber of sampling points;
(d) type of sampler used;
(e) averaged particle-size distribution for all sampling points, in percent finer than indicated size (mm).

Note: Bed material collection was not performed for miscellaneous stations in Ontario during the period 1966-1983.

MSDC66-83:3 - The table of Bedload Particle-size gives:

(a) date and time of each sampling;
(b) discharge at time of sampling (m^3/s);
(c) number of sampling points;
(d) type of sampler used;
(e) averaged particle-size distribution for all sampling points, in percent finer than indicated size (mm).

Note: Bedload collection was not performed for miscellaneous stations in Ontario during the period 1966 - 1983.

Sediment Data Reference Index Canada Environment Canada, Inland Waters Directorate, Water Resources Branch, Water Survey of Canada, Ottawa, Canada.

The Index is a tabulation of all Canadian sediment stations, subdivided by province or territory, giving for each station:

(a) its number and name;
(b) the type of operation;
(c) its latitude, longitude, land description and drainage area;

and a list of the particular years of availability of each of the following five categories of data:

(d) suspended sediment (concentration and load);
(e) dissolved solids concentration;
(f) water temperature;
(g) particle size distribution (point and depth integrating);
(h) bed load (volume or load, and particle size) and bed material particle-size.

Historical Sediment Data Summary Canadian Rivers Environment Canada, Inland Waters Directorate, Water Resources Branch, Water Survey of Canada, Ottawa, Canada.

wDS63-78:1 - The summary of Monthly Mean Suspended Sediment Load gives, for each year of sediment load record:

(a) the monthly mean load (tons or tonnes per day) for each complete month of daily load data;
(b) the mean of all the monthly means

HSDS63-78:2 - The Annual Extremes of Suspended Sediment Concentration and Load and Annual Total and Annual Mean Suspended Sediment Load gives:

(a) the annual maximum and minimum daily suspended sediment concentration (mg/L) and load (tons or tonnes per day) for each year in which daily records are available for the entire year or standard period within the year e.g. March to October;
(b) the annual total load (tons or tonnes), and the annual mean load (tons or tonnes per day) for each year in which daily mean loads have been determined for the entire year. If a standard period (e.g. March to October) has been selected, the figure applies to only those months.

The Extreme Recorded for the Period of Record, of Daily Mean Suspended Sediment Concentration and Daily Mean Suspended Load, are identified in the table by an asterisk.

HSDS63-78:4 - The Summary of Monthly and Annual Total Volumetric Bed Load gives:

(a) the monthly total (cubic yardsor metres) for each month of record;
(b) the annual total (cubic yards or metres) if monthly records exist for the complete year;
(c) the mean of all monthly totals;
(d) the mean of all annual totals.

Note: There was no computation of volumetric bed load in Ontario during the period covered by the *Historical Summary*.

Data were reported in the Imperial unit system before 1978, and the SI unit system starting with the 1978 edition. The format of pre-1978 Historical Summaries varies slightly from the one given above.

3.0 Notes on Data Interpretation

3.1 Introduction

Some notes and suggestions are offered in this chapter to aid the user of sediment information published by the Water Resources Branch with appropriate usage and interpretation of the data. The chapter is organized around a number of user-oriented questions, such as:

- Can sediment concentration and load values be extrapolated to nearby streams?
- Are sediment concentrations and loads fairly constant from year to year?
- Can conclusions about the sources of sediment be made from the available sediment concentration and load data?
- What systematic or random errors might be expected in the data?

Questions involving sediment data interpretation not addressed in this chapter may be pursued with Sediment Survey Section personnel of the Water Resources Branch at either the Regional Office in Guelph or the Main Office in Ottawa.

3.2 Seasonal and Temporal Patterns

- To what extent do sediment concentrations and loads vary from season to season?
- Do suspended sediment concentrations and loads vary significantly from year to year at a given stream station?
- In other words, can I consider sediment loads determined from one or two years of measurement to be representative of longer term sediment loadings at that station?

Suspended sediment concentrations and loads vary widely in Ontario streams. Concentrations at individual stations can be expected to have a range of values of three to four orders of magnitude (i.e. 10's to 1000's of mg/L); and sediment loads over seven orders of magnitude. Table 3.1 reports the historical extremes of concentration for five stations with at least 10 years of record, and operating in 1987. Table 3.2 reports daily mean loads and historical extremes for the same five stations; and Table 3.3 lists other relevant characteristics, including annual runoff and sediment yield.

The concentration data reveal a wide average annual range of values at each station, with average minimum values less than about 30 mg/L and average maximum values greater than about 700 mg/L. The range in absolute extremes is wider, with most minima less than 10 mg/L, and maxima between about 1500 and 6000 mg/L. The maximum value recorded is 8170 mg/L, on Big Otter Creek near Calton, on September 26, 1984.

Since daily suspended loads are determined as the product of suspended sediment concentration and daily discharge, and since concentration and discharge values for streams in the province range over four and three orders of magnitude respectively, it follows that the daily loads can range over seven orders of magnitude. Such a range is revealed in Table 3.2, the daily suspended sediment loads in the Credit River at Erindale having varied between 0.24 and 88,200 t/d, and the loads in the South Nation River near Plantagenet Springs between 2.36 and 157,000 t/d. These numbers are consistent in order of magnitude with estimates and computed values published earlier by Holeman (1968), Stichling (1973) and Dickinson et al. (1975); and are a fraction of sediment yields experienced in mountainous and/alluvial regions of Canada.

It is also known that suspended sediment concentrations and loads in streams in the province typically exhibit a seasonal pattern, roughly following the seasonal trends of discharge, as illustrated in Figure 3.1. However, it should be noted that sediment concentration is not singularly determined by discharge (the relationship, or lack of relationship, between suspended sediment concentration and stream discharge is discussed in some detail in Section 3.5). In general, the lowest annual concentrations are observed during the low-flow winter period (concentrations on small streams commonly drop to zero or near zero for extended winter periods), and the highest concentrations are observed during the spring snowmelt period. Concentrations decline in summer as streamflows decline, and often rise slightly in fall. Superimposed on this overall pattern are significant shorter-term fluctuations associated with individual runoff and sediment-generating events.

The annual distribution of sediment loads strongly reflects the annual patterns of both concentrations and discharge (again illustrated in Figure 3.1). Sediment loads, therefore, also follow a cyclical pattern, with low values during winter, followed by high values in spring, a summer recession, and a second period of slightly increased loads during fall.

To illustrate variations that might be expected in seasonal patterns, monthly sediment yield (i.e. sediment load per unit area) is plotted for the five watersheds selected above in Figure 3.2. Differences in yields are associated with differences in both discharge and concentration (which, in turn, is influenced by discharge and sediment supply). Table 3.3 and Figure 3.2 illustrate the importance of sediment supply, since all stations experience similar annual runoff (except the North Magnetawan River); whereas there is a wide range in yield. In particular, the Humber River produces about double the sediment yield of Big Creek and the Nottawasaga River, which in turn produce about two and three times the sediment yields of the North Magnetawan River and Halfway Creek. These data are particularly notable, since the North Magnetawan River has about double the runoff of the other stations.

In Figure 3.3 and Table 3.4, sediment yield and load data are presented as a percent of the annual total, to better isolate the differences in timing. It is evident from these data that the spring portion of the annual load cycle contributes the bulk of the annual suspended load (i.e. in the order of 75%). This pattern closely parallels the seasonal distribution of flood occurrences in Ontario (as noted by Dickinson, 1972); however, the significance of the high spring months is greater for sediment load than for discharge. For example, for Halfway Creek, 40% of the annual runoff and 66% of the annual sediment load occur in May.

Suspended sediment concentrations and loads vary not only from season to season but also from year to year, as revealed in Table 3.1. The data in this table reflect variations in sediment concentrations and discharge that can be expected for reasonably unchanged source conditions (i.e. land uses associated with prime sediment source areas have not altered significantly). The maximum annual sediment loads are from 3 to 8 times the minimum annual loads, a wide range considering the relatively short periods of record. Therefore, single year determinations of suspended sediment loads do not provide precise estimates of the long term mean. There is some evidence that mean and median values of 10 or more years of data provide reasonably good indices of the central tendency of annual suspended sediment loads in the province.

It is evident then that suspended sediment concentrations and loads vary significantly throughout the year and from year to year in Ontario streams. Seasonal variations and pattern, and year to year variations, characteristics of each stream should be ascertained and kept in mind for many applications of suspended sediment data.

Table 3.1 Range of values of sampled suspended sediment concentration for 5 selected stations[1]

Station Name	Suspended Sediment Concentration			
	Average Annual Range (mg/L)		Absolute Range (mg/L)	
	Maximum	Minimum	Maximum	Minimum
Ausable River near Springbank	889	16	1630	7
Big Creek near Walsingham	707	10	1860	1
Big Otter Creek near Calton	3067	33	8170	11
Credit River at Erindale	1204	2	3030	0
South Nation River near Plantagenat Springs	848	17	5890	4

Note: 1. The 5 stations have at least 10 years of record and were operating in 1987.

Table 3.2 Ranges of values calculated for daily suspended sediment loads for 5 selected stations[1]

Station	Mean Daily Load ($t\ d^{-1}$)	Range of Loads ($t\ d^{-1}$)		Mean Daily Yield ($t\ km^{-2}\ d^{-1}$)	Range of Yields ($t\ km^{-2}\ d^{-1}$)	
		Max	Min		Max	Min
Ausable River near Springbank	153	33,200	0.87	0.458	99.4	0.0026
Big Creek near Walsingham	70.0	3,690	0.22	0.307	16.2	0.00096
Big Otter Creek near Calton	485	34,100	2.31	1.80	127	0.00859
Credit River at Erindale	142	88,200	0.24	0.444	276	0.0w76
South Nation River near Plantagenet Springs	1,220	157,000	2.36	0.830	107	0.00161

Note: 1. The 5 stations had at least 10 years of record and were operating in 1987.

Table 3.3 Characteristics of selected sediment stations.

Station	Record used for: runoff analysis	Record used for: sediment yield analysis	Drainage Area (km^2)	Annual Runoff (mm)	Annual Sediment Yield (tonnes/km^2)
Big Creek near Walsingham	1962-86	1966-86	591	356	43.3
Humber River at Elder Mills	1962-86	1966-86	303	263	86.7
Nottawasaga River near Baxter	1962-86	1983-86	1180	258	42.2
North Magnetawan River above Pickerel Lake	1968-83	1978-82	149	614	22.3
Halfway Creek at Moosonee	1976-84	1978-83	133	277	13.4

Table 3.4 Seasonal distribution of suspended sediment loads for selected rivers in southern Ontario

	Seasonal Load as a % of the Annual Load		
Station Name	Spring[1]	Summer[2]	Fall/Winter[3]
Ausable River near Springbank	74	7	19
Big Creek near Walsingham	68	14	18
Big Otter Creek near Calton	76	7	17
Canagagigue Creek	84	1	15
Credit River at Erindale	84	7	9
Halfway Creek at Moosonee	72	14	14
Humber River at Elder Mills	85	6	9
North Magnetawan River above Pickerel Lake	62	18	20
Nottawasaga River near Baxter	81	11	8
South Nation River near Plantagenet Springs	84	2	14
Thames River	64	7	29
Mean Values	76	8	16

Notes: 1. February through May 2. June through September 3. October through January

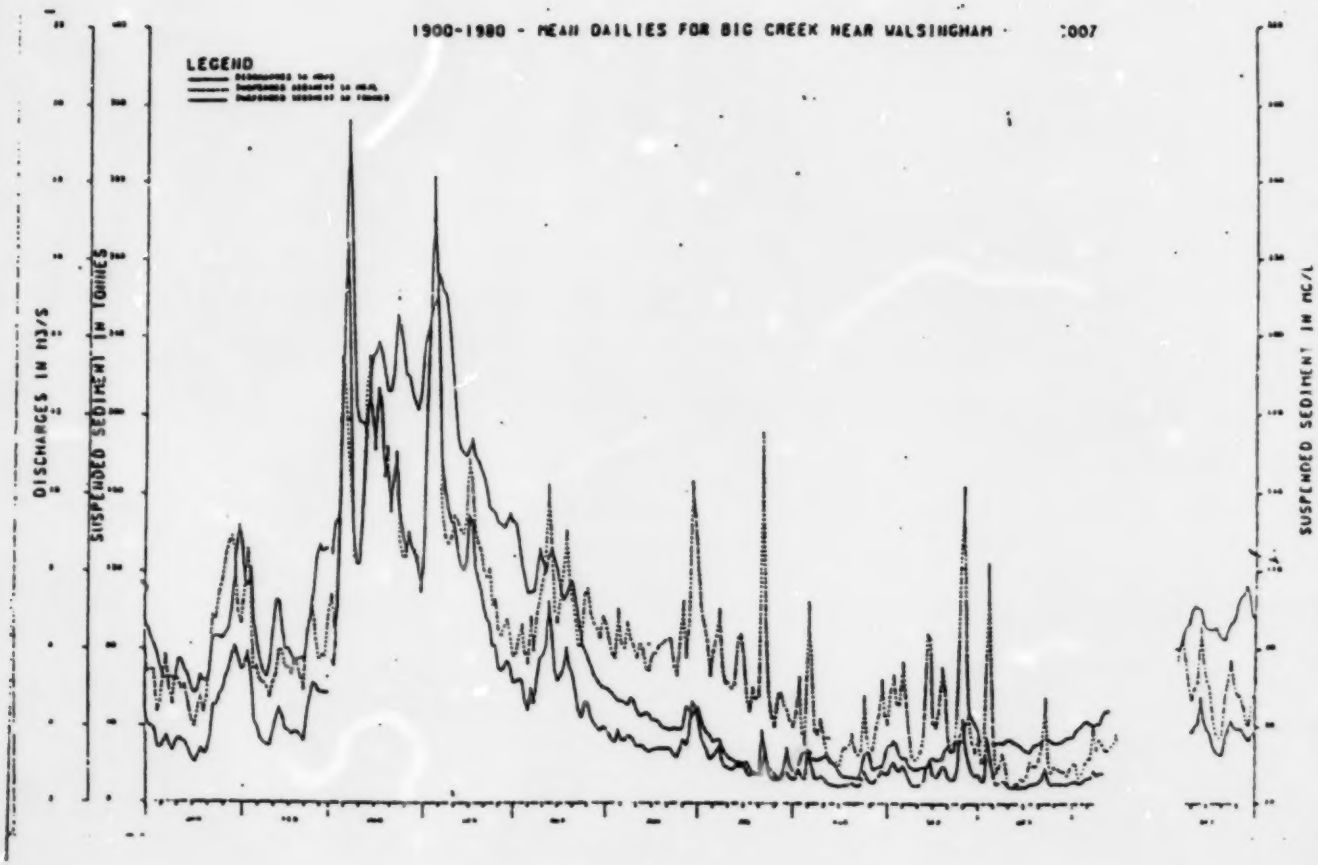
1900-1980 - MEAN DAILIES FOR BIG CREEK NEAR WALSINGHAM
LEGEND
DISCHARGES IN M3/S
SUSPENDED SEDIMENT IN TONNES
SUSPENDED SEDIMENT IN MG/L

Figure 3.1 Mean daily discharge, suspended sediment concentration, and suspended sediment load for Big Creek near Walsingham.

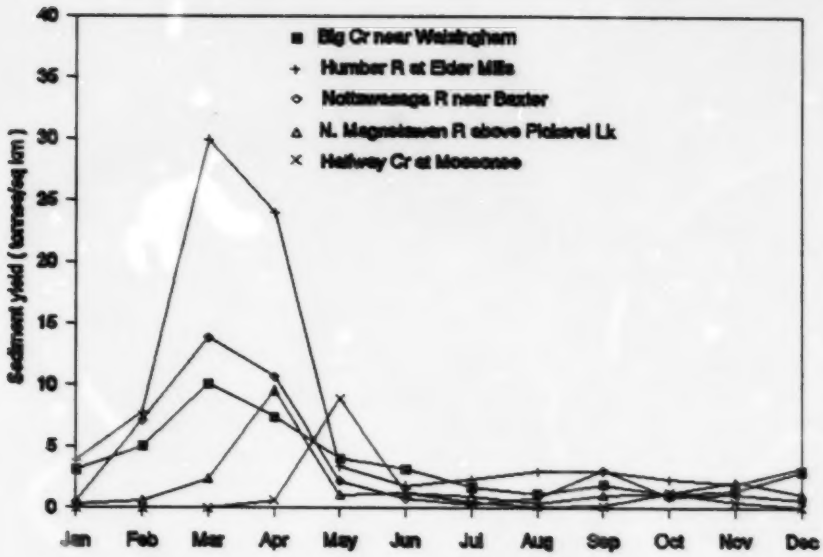

Figure 3.2 Monthly sediment yield for five Ontario watersheds

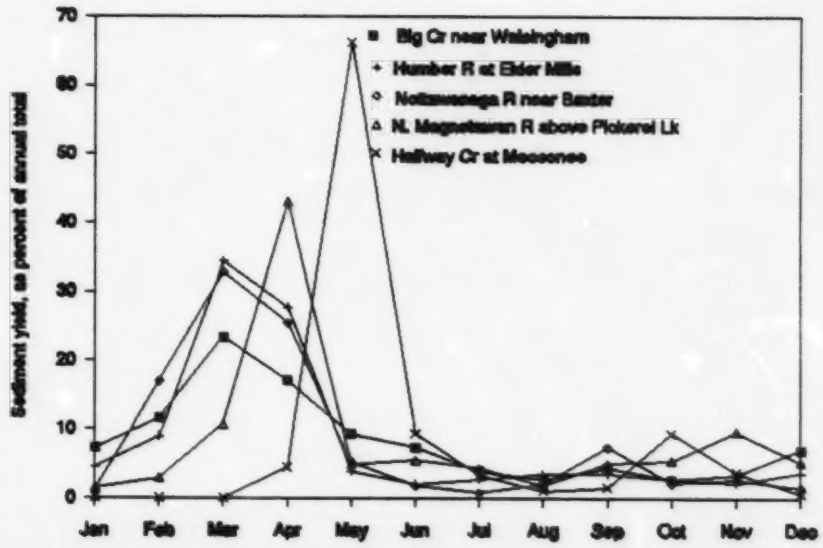

Figure 3.3 Monthly sediment yield for five Ontario watersheds expressed as percent of total to better illustrate latitudinal effects.

3.3 Load Duration Curves

* Is it true that most of the annual suspended sediment load is transported downstream in Ontario watersheds in a very few days each year?

* What is the role of extreme flows (e.g. 10 year floods) in the transport of suspended sediment?

Suspended sediment duration curves, such as those presented in Figures 3.4, 3.5 and 3.6 are particularly useful for exploring the length of time associated with flow events during which sediment is transported. Figure 3.4 and 3.5 are conventional plottings of the percentage of time which daily suspended sediment loads (expressed as yield) can be expected to be equalled or exceeded over the long term. Figure 3.4 is a representation of Suspended Sediment Duration Curves found in WRB publications. Figure 3.6 offers another representation of the same data, plotting the percentage of the total suspended load (carried by each river) contributed by suspended loads greater than or equal to selected values versus the percentage time that these selected values are expected to be equalled or exceeded. Figures 3.4, 3.5 and 3.6 clearly reveal that a large percentage of the annual suspended sediment load in Ontario streams is transported downstream in a very short period of time each year. For example, a majority of the annual load (i.e. >65%) and, in most cases, the vast majority of the annual load (i.e. 80 to 90%) is expected to be delivered in less than 10% of the time (i.e. less than 36.5 days each year). For all rivers selected for Figure 3.5, except the Thames River at Ingersoll, more than 60% of the annual load is transported in less than 16 days each year; for the Thames, more than 50% is transported in 16 days. The suspended sediment duration curves essentially reveal that the movement of suspended sediment in Ontario streams is an event-oriented process.

When the above results are compared with similar statistics for streamflow itself, the extent to which suspended loads are event-oriented and linked to extremal flow events is revealed. Figure 3.7, a diagram comparable to Figure 3.6 but developed from streamflow data, reveals the daily streamflow equalled or exceeded 10% of the time accounts for 40 to 70% of the total flow while flows equalled or exceeded 5% of the time account for 25 to 55% of the flow. Although suspended sediment loads are strongly linked to streamflow, it is clear that the daily sediment load variable is more extreme-event oriented than the equivalent flow variable.

The sediment load duration curves, and the degree of difference between flow and load duration curves, are highly variable across the province. Attempts made to explain observed variations in terms of watershed location, drainage area, and other characteristics have been largely unsuccessful. It would appear that the shapes of the dimensionless flow and sediment duration curves are dominated by a few large flow events each year, and by the sediment supply mechanisms active during these events. Therefore, simple spatial and causal patterns have not emerged.

On the basis of the sediment duration characteristics of Ontario streams, however, it can be concluded that the determination of reliable estimates of suspended sediment loads is contingent upon the application of a sediment sampling scheme that ensures the obtaining of good sediment samples during the brief period of each year when most of the suspended load is delivered.

The duration curve analysis which indicates that the bulk of suspended sediment is transported during major events begs the question: How much of the load can be expected to be transported by events with long return periods? Is there any point in measuring loads during much of the rest of the time? Extreme value analysis of the annual series of maximum daily suspended sediment loads has yielded answers to these questions. On the basis of an assumed log-normal probability distribution, Table 3.5 summarizes suspended sediment loads for selected return periods for selected basins. A study of Table 3.5, in conjunction with Figure 3.6, reveals that the daily sediment loads with

return periods of two years or greater (i.e. loads which have a probability of 0.5 of being equalled or exceeded in a given year) account for approximately 40% of the total sediment load. Annual peak events contribute a similar, or slightly larger, significant portion of the total load. In comparison, on the basis of Figure 3.7, daily streamflows with return periods of two years or greater account for about 8 to 20% of the total flow. Therefore, the reliable estimation of sediment loads requires careful sampling of significant events, including sediment load occurrences with return periods of two years or greater and annual peak events.

Table 3.5 Extreme daily suspended sediment loads in selected Ontario streams

	Daily Suspended Yields Yields ($t\ km^{-2}\ day^{-1}$) for Return Periods of			
Station Name	2 years	5 years	10 years	25 years
Ausable River near Springbank	8.44	15.3	20.6	28.8
Big Creek near Walsingham	6.21	10.7	14.2	19.1
Big Otter Creek near Calton	47.6	74.4	92.9	119
Canagagigue Creek	62.6	104	135	181
Credit River at Erindale	37.6	103	172	303
Humber River at Elder Mills	35.0	55.1	68.4	88.0
South Nation River near Plantagenet Springs	16.8	38.8	59.2	93.2
Thames River	4.30	8.35	11.8	17.2

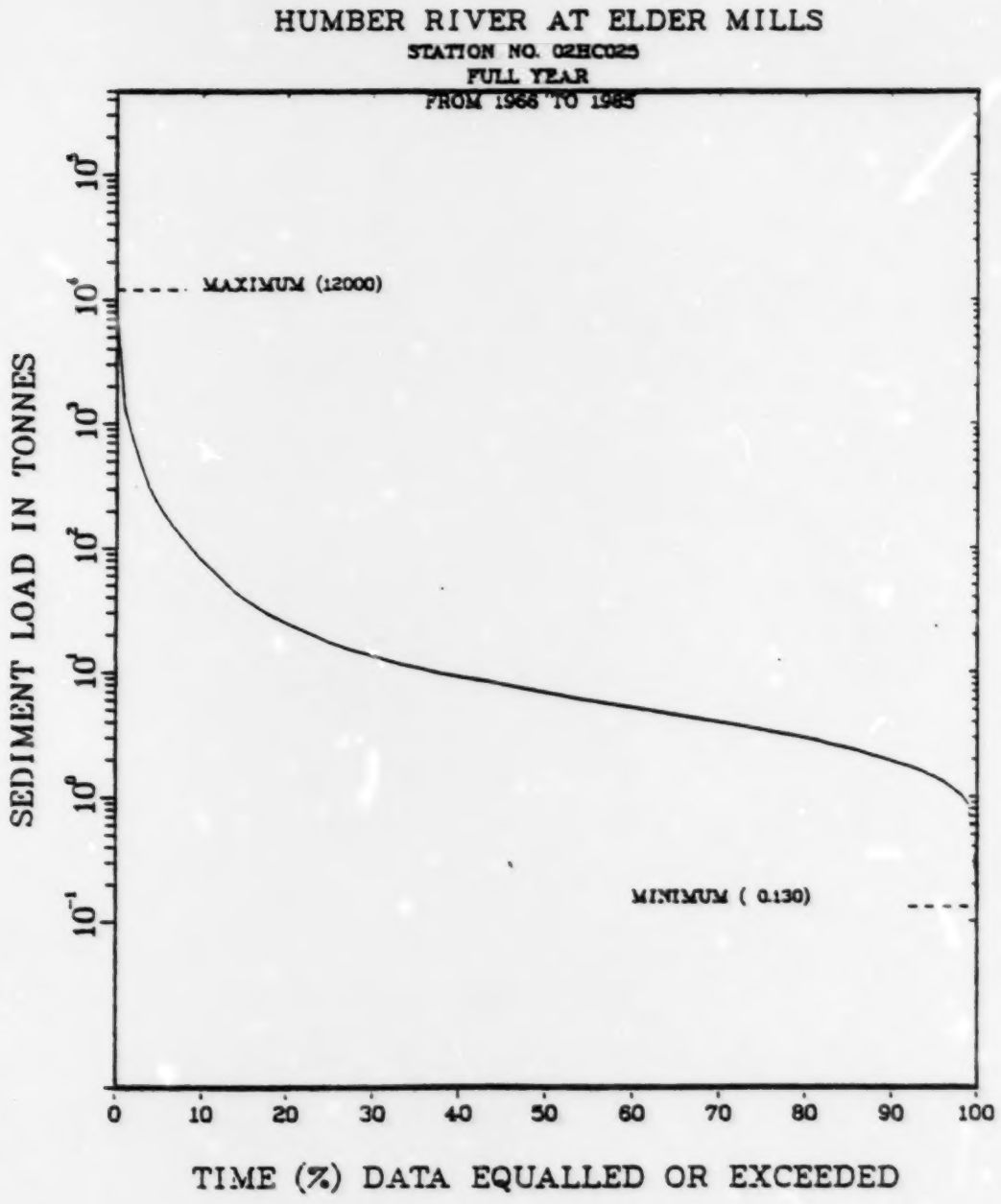

Figure 3.4 **Daily suspended sediment duration curve**

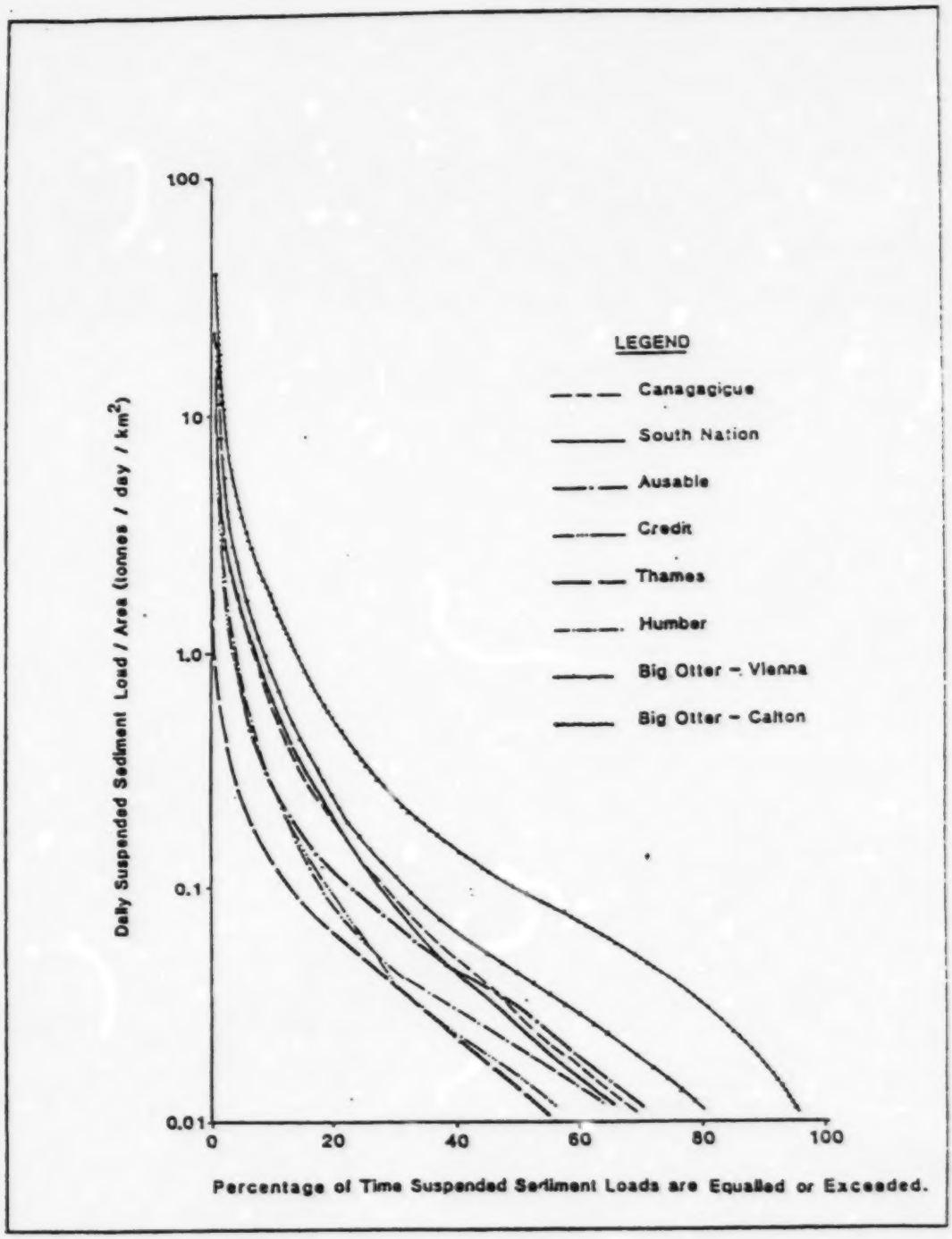

Figure 3.5 Daily suspended sediment load duration curves for selected stations in southern Ontario.

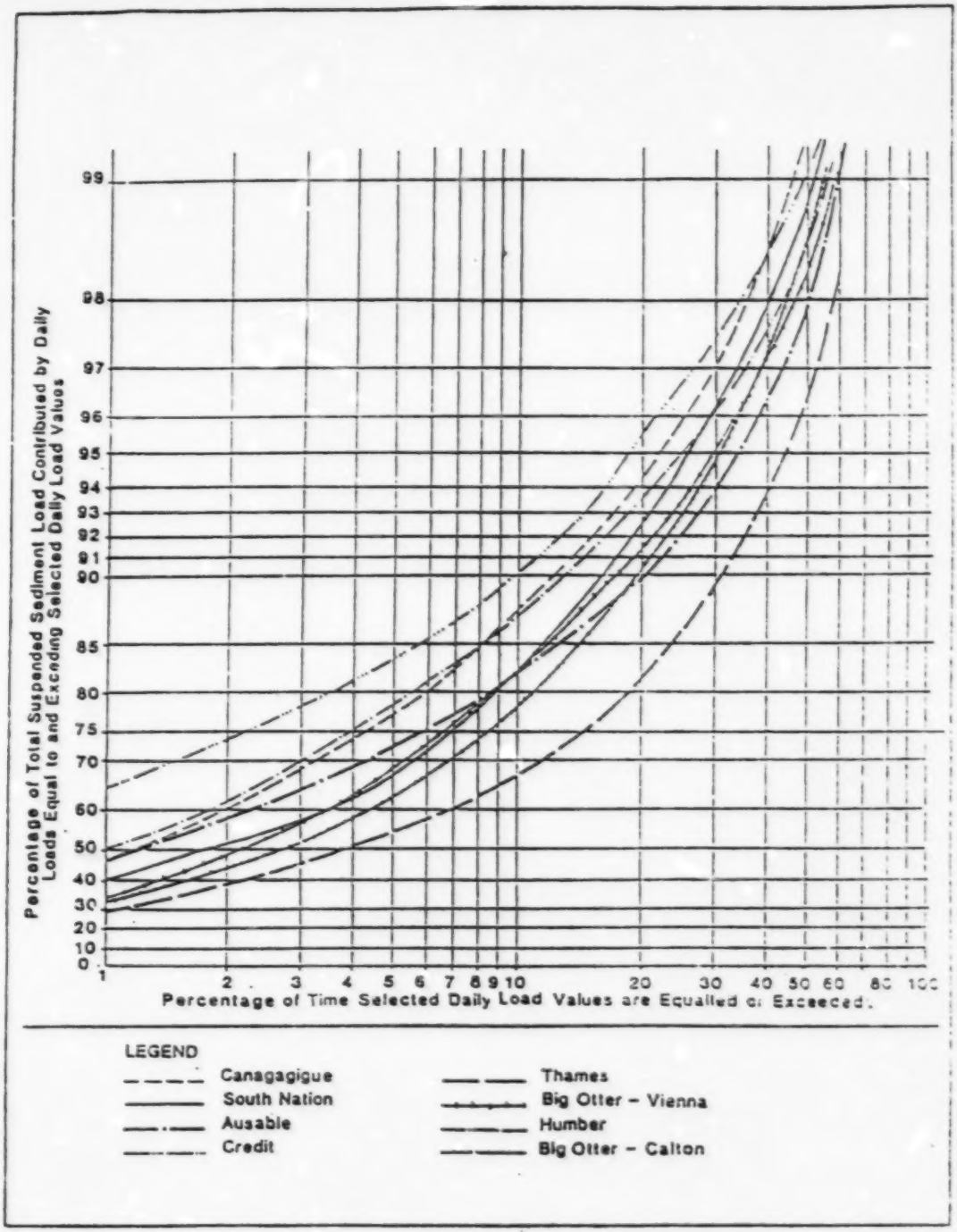

Figure 3.6 Dimensionless sediment load duration curve for selected stations in southern Ontario.

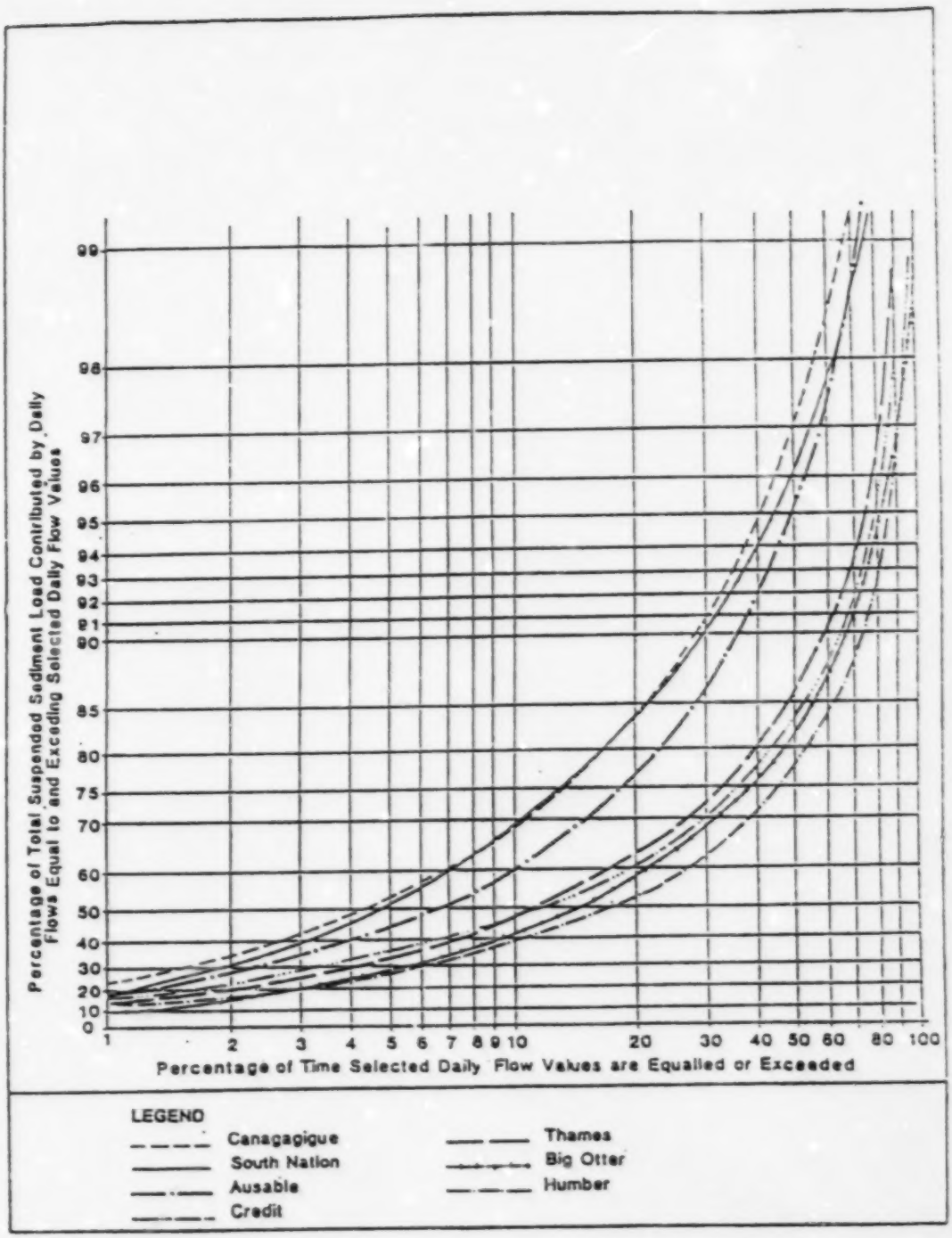

Figure 3.7 Dimensionless streamflow duration curves for selected stations in southern Ontario.

3.4 Spatial Trends

- Can sediment concentrations and/or loads be extrapolated to nearby stations, at upstream or downstream locations or other watersheds?
- Is there a spatial pattern to suspended sediment concentrations and loads in parts of the province?

There is evidence of spatial patterns in suspended sediment concentrations and loads across Ontario, and these patterns result from spatial differences in the climatic and watershed conditiws governing runoff-generation, and in the many processes (geologic, hydrologic, and anthropomorphic) governing sediment supply. However, the broad variability of sediment concentration within the year at individual stations (noted above in Section 3.2) is often much greater than the variability of concentration between stations. This large variation in sediment concentration in combination with the nonuniform distribution of provincial sediment stations makes it difficult to identify general spatial patterns. Meaningful spatial trends in runoff which appear to affect suspended sediment concentrations and loads are noted here, and other factors governing sediment concentrations and/or loads are discussed in Section 3.6.

A broad latitudinal trend, associated with large-scale climatic controls, has been identified in the monthly distribution of runoff. Figure 3.8 reveals variations in this distribution at the five selected stations. The five stations are reasonably similar in terms of drainage area and period of record, and all except Big Creek are unregulated. The watersheds are also all oriented on an approximately north/south axis. Their total annual runoff is similar, with the notable exception of the North Magnetawan River, which experiences about double the runoff of the other basins; but monthly runoff, particularly when expressed as a percent of the annual total (Figure 3.9), reveals latitudinal trends. Two features are particularly notable. First, the timing of the maximum spring runoff occurs later at the more northern latitudes, shifting from March for Big Creek and the Humber River to April for the Nottawasaga River and the North Magnetawan River to May for Halfway Creek. Second, the peakedness of the spring runoff clearly intensifies with latitude. On Big Creek, only 17% of the annual runoff occurs in the maximum month, compared to 40% for Halfway Creek. The timing and peakedness of spring runoff, and linkages to latitudinal location, were noted by Dickinson (1972), who found that 60 % of the annual runoff peaks from 25 basins in southern Ontario occurred in March and April, while 80 % of the annual runoff occurred between February and May. Seventy (70) percent of the annual flood extremes from northern Ontario basins occur in a one month period in May and June. Between July and November all five streams experience similar runoff behaviour, although the two most northern stations experience a better-defined mid-autumn rise.

Not surprisingly, the distribution of annual sediment loads reveals the spatial trend noted above in relation to broad latitudinal differences, as shown in Figures 3.2 and 3.3. In addition to this trend, suspended sediment concentrations and loads can vary dramatically from station to station in close proximity to one another, as demonstrated in Figure 3.10. The broad latitudinal trend is linked primarily to variations in discharge generation, with differences in sediment source conditions playing an additional role. The more localized variations are due predominantly to differences in sources of suspended sediment. Therefore, if sediment sources are known to be similar in nearby watersheds (be they adjacent, upstream or downstream), the extrapolation of a seasonal pattern of sediment concentration characteristic of the latitude and the sediment source conditions is appropriate. In areas where the sources of suspended sediment vary dramatically - and this situation is not unusual in Ontario, either between adjacent basins or between upstream and downstream basins (as illustrated in Figure 3.10 and discussed further in Section 3.6) - the extrapolation of suspended sediment concentration patterns should be undertaken with much caution.

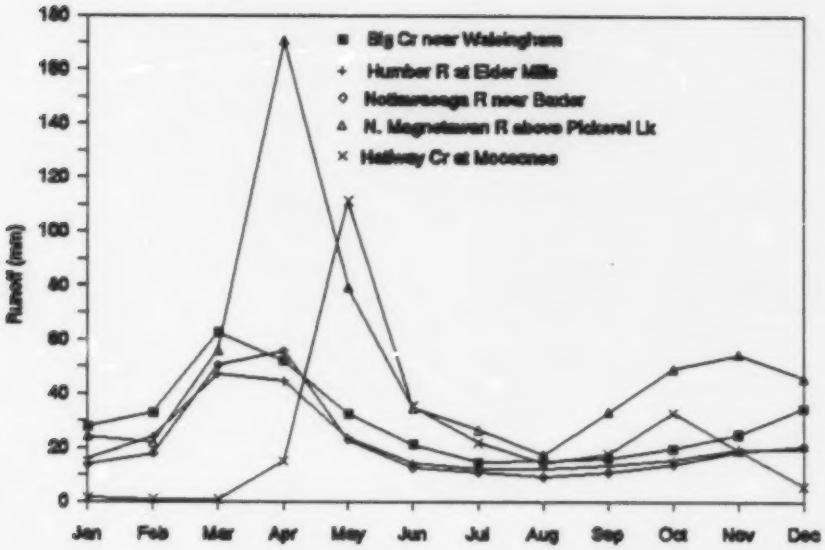

Figure 3.8 Monthly runoff for five Ontario watersheds. Drainage areas range from 133 to 1180 km^2, and all watersheds except Big Creek are unregulated.

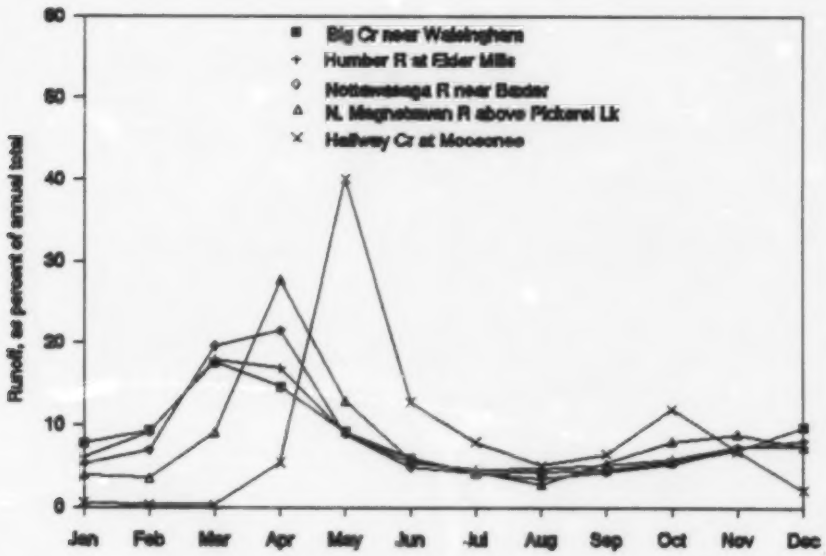

Figure 3.9 Monthly runoff for five Ontario watersheds, expressed as percent of annual total to better demonstrate latitudinal effects. Drainage areas range from 133 to 1180 km^2, and all watersheds except Big Creek are unregulated.

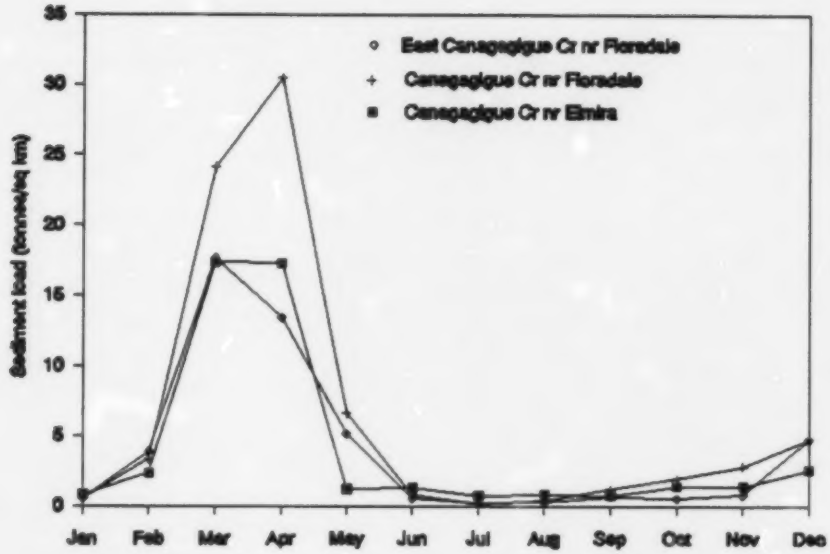

Figure 3.10 Monthly sediment load for three stations in the Canagagigue Creek watershed

3.5 Suspended Sediment Rating Relationships

* To what extent is suspended sediment concentration related to stream discharge?
* Can sediment concentration be predicted from discharge values?

The mathematical relationship between suspended sediment concentration and stream discharge has been referred to as a suspended sediment rating curve. Extensive data collected in many areas of the world suggest that this relationship, where it exists, can be expected to be exponential in form, as follows:

$$C = a*Q^b \qquad \text{..... [3.1]}$$

where C and Q represent concentration and discharge, respectively, and "a" and "b" are constants.

Analysis of Ontario sediment data rewals that suspended sediment concentration and discharge values can be represented by equation [3.1]. However, the relationships are highly variable, not only between stations but also at individual stations, as illustrated in Figures 3.11 and 3.12. The between- and within-station variability is documented in Table 3.6, which reports the results of many regression analyses conducted on data from 23 sediment stations with at least 5 years of continuous or seasonal record. The analyses are based on plots of mean daily concentration vs mean daily discharge values for days on which concentration samples were collected. Between stations, the parameter "a" varies from 0.2 to 231.6, and the exponent "b" varies from -0.13 to 1.19, each constant demonstrating a range of about 2 orders of magnitude. Note that when b= 0, none of the variation in sediment

concentration is explained by discharge. Positive values of "b" mean that concentration and discharge are directly related, while negative values mean that they are inversely related. Values near 0 indicate that the relation between them is very weak.

Differences in rating curves between stations are not easily associated with broad differences in physiographic and land use characteristics. Variations even within similar physiographic regions of the province appear to be of nearly the same magnitude as the total province-wide variation. For example, Big Creek near Walsingham, and the two stations on Big Otter Creek, all three with similarities in drainage area, slopes, soils, and land use, show a range in "a" of 8.8 to 38.7 and a range in "b" of 0.79 to 1.11. Similarly, the three stations on Canagagigue and East Canagagigue Creeks show "a" to range from 22.3 to 78.4 and "b" to range from 0.39 to 0.95.

There is some indication that basin size may influence the exponent of the suspended sediment rating curve (Figure 3.13). For watersheds below about 1800 km^2, the values vary without apparent pattern between -0.13 and 1.19. However, the exponent values for the 5 larger basins all lie between 0.31 and 0.54. Although insufficient for a conclusive comment, these data may indicate that above about 1800 km^2, most watersheds contain a similar range of supply-governing processes, such that a consistency in the role of discharge is apparent. Sediment supply processes in smaller basins may be highly inconsistent between basins, and specific processes may dominate stream sediment concentrations. However, the data could simply reflect that the larger basins show less difference between instantaneous and mean daily discharge than small basins. Therefore, qualitative attempts to identify consistent explanations for inter-basin differences have been largely unsuccessful, with the possible exception of drainage area.

The within-station variability of concentration versus flow data is also large. Table 3.6 reports the ranges of values of "a" and "b" found by separate analysis for each year of record. Each station demonstrates a wide range in both sets of values. This finding helps explain the difficulties encountered in isolating the differences between stations. Also, since year-to-year variability at a station is not expected to be as large as between-station variability, this result suggests that seasonal differences and differences in timing of sampling may be partly responsible.

As sediment supply processes are not expected to act in a steady manner throughout the year, the possible seasonality of suspended sediment rating curves was investigated by examining plots for each individual year of record, for the 23 stations of Table 3.6, for which the data were identified by month. This analysis showed that data collected at similar times of the year tend to group together in a distinct pattern, rather than uniformly app$xring throughout the range of the annual data. To quantify this effect, optimal rating relationships ($C = a*Q^b$) were found for each month. The results for four stations are shown graphically in Figures 3.14 through 3.17. Each station demonstrates a wide range in the exponent "b", the range being typically about 1.0. For example, the monthly exponent values for Big Creek near Walsingham vary from about 0.6 to 1.6; for Big Otter Creek the range is 0.9 to 1.9; for Ausable River near Springbank the range is 0.2 to 1.3, and for the Humber River station, the range is about 0.7 to 1.7. Many stations exhibit a cyclical seasonal pattern in "b", with peaks during spring and fall, although there is little consistency evident in the timing and the absolute amplitudes. The pattern of the constant "a" is also approximately cyclical, and tends to mirror that of the exponent. However, even stations representing basins of similar size, and in close proximity to each other, show differences in the timing of seasonal patterns of "a" and "b". This point is well illustrated by comparing the seasonal patterns for Big Otter Creek and Big Creek, in Figures 3.16 and 3.17.

The Ontario sediment data reveal, therefore, that although suspended sediment concentration can be related to stream discharge with an equation of the form $C = a*Q^b$, the parameters of that relationship vary significantly from station to station, and from year to year and seasonally at individual stations. The year-to-year variability is partly explained by the seasonal patterns in the rating curves, and by year-to-year variations in suspended sediment sampling. The between-station variability and the existance of seasonal patterns indicate that sediment concentration is dominated by supply. The difficulties experienced in characterizing the variability suggest that specific supply-controlling factors operating at scales smaller than those of broad regional divisions are largely responsible for determining suspended sediment concentrations. Suffice it to say, suspended sediment rating curves should be used with much caution in the Ontario environment.

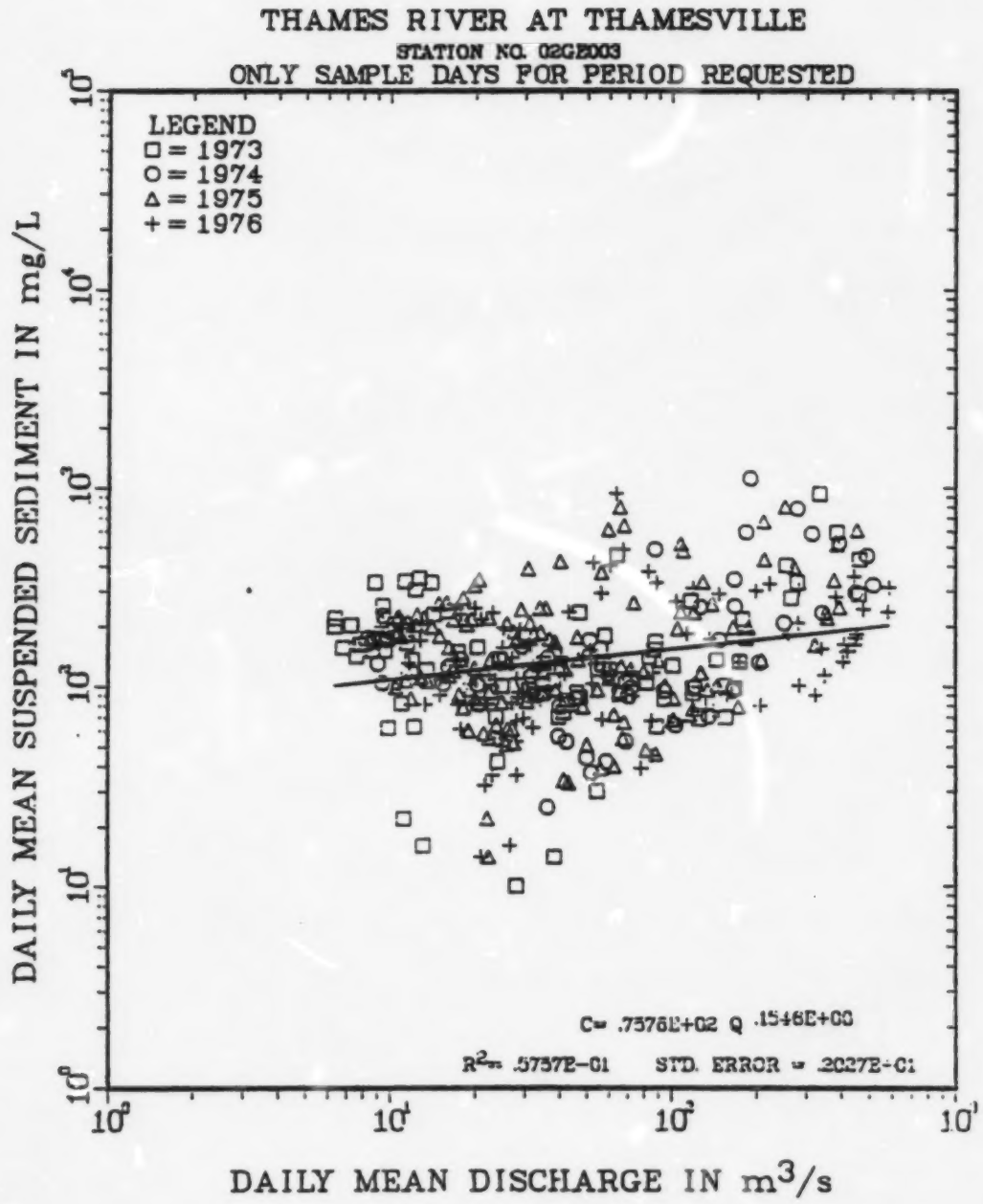

Figure 3.11 Daily mean suspended sediment vs daily mean discharge for Thames River at Thamesville.

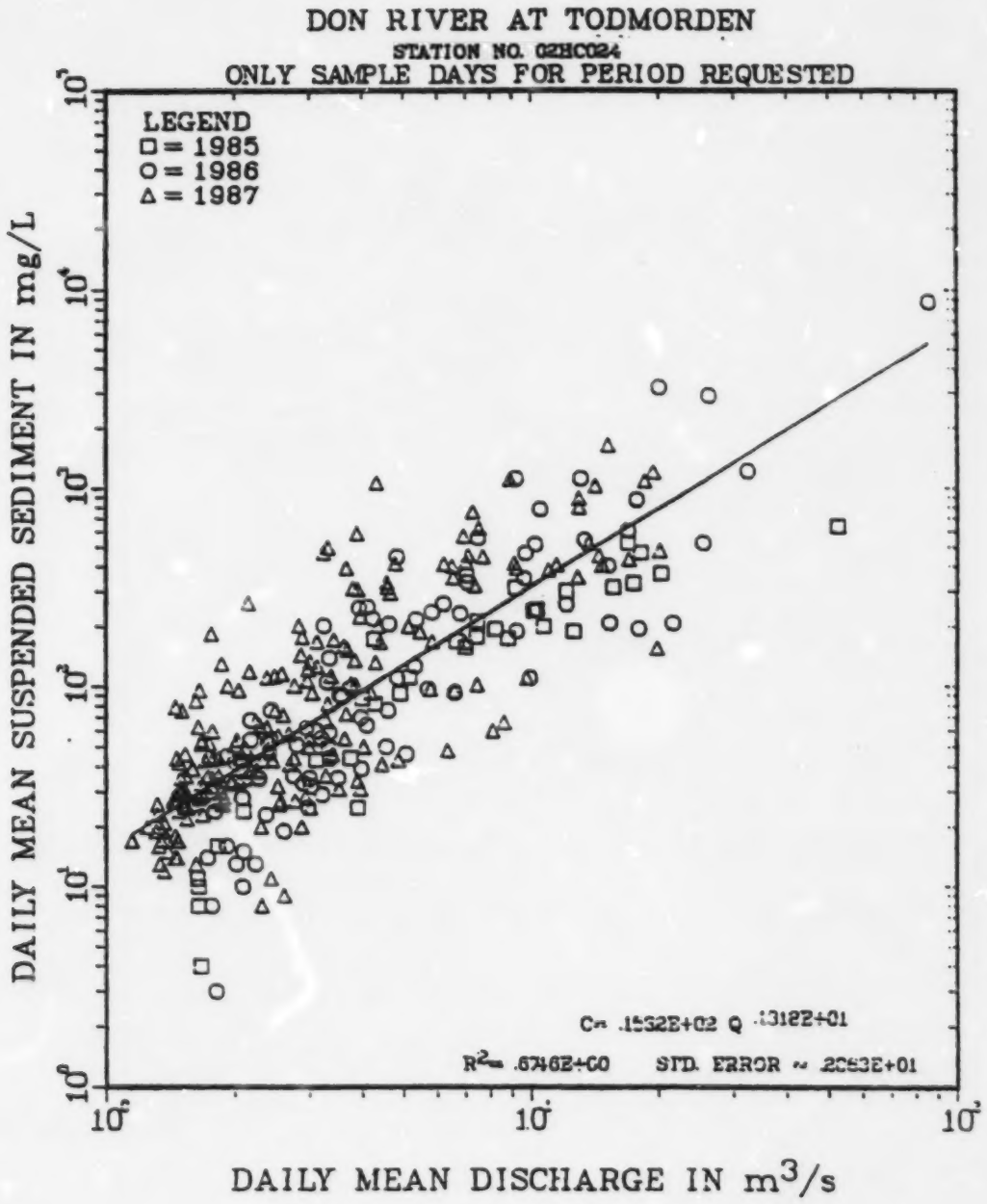
DON RIVER AT TODMORDEN
STATION NO. 02HC024
ONLY SAMPLE DAYS FOR PERIOD REQUESTED
LEGEND
□ = 1985
○ = 1986
△ = 1987
DAILY MEAN SUSPENDED SEDIMENT IN mg/L
DAILY MEAN DISCHARGE IN m3/s
C= .1532E+02 Q .1312E+01
R2= .6746E+00 STD. ERROR = .2053E+01

Figure 3.12 Daily mean suspended sediment vs daily mean discharge for Don River at Todmorden.

Table 3.6 Values of regression constants in the concentration/discharge relationship $c = a*Q^b$ for selected sediment stations in Ontario.

Station Name[1]	Drainage Area (km^2)	Record Length[2] (years)	Average Values[3] a	Average Values[3] b	r^2 ([3])	Range of Values[4] a max	Range of Values[4] a min	Range of Values[4] b max	Range of Values[4] b min
Ausable River near Springbank	865	18	91.6	0.04	.0075	141.1	57.3	0.20	-0.13
Big Creek near Walsingham	591	21	8.8	1.11		29.3	3.1	1.45	0.48
Big Otter Creek near Calton	676	13	38.7	0.79	0.54	101.2	20.8	1.13	0.44
Big Otter Creek near Vienna	697	12	14.5	1.08	0.65	32.3	8.8	1.24	0.80
Canagagigue Creek near Elmira	118	7	22.3	0.69	0.54	25.2	18.6	0.85	0.58
Canagagigue Creek near Floradale	17.9	11	78.4	0.39	0.38	163.8	46.3	0.71	0.27
Credit River at Erindale	795	15	2.6	1.11	0.53	15.4	0.6	1.64	0.41
East Canagagigue Creek near Floradale	27.7	11	60.2	0.95	0.60	91.5	45.1	1.27	0.77
Farewell Creek at Oshawa	58.5	6	43.0	0.46	0.21	70.5	23.2	0.76	0.41
Halfway Creek at Moosonee	133	6	18.0	-0.13	0.05	63.7	9.4	0.25	-.20
Harmony Creek at Oshawa	41.6	6	121.5	0.49	0.34	72.2	185.8	0.90	0.34
Humber River at Elder Mills	303	22	26.8	1.19	0.60	15.0	66.9	1.53	0.86
Humber River at Weston	800	12	22.2	0.85	0.63	12.3	44.5	1.01	0.66
Maitland River near Donnybrook	1760	5	2.7	0.45	0.32	5.5	1.7	0.59	0.33

Notes:
1. The stations listed are those with at least 5 years of continuous or seasonal records and load calculations.
2. The record length refers to pre-1988 data.
3. Average values are based on regression analysis of all available data.
4. The values listed under Range of Values are based on a seperate analysis for each year of record.
5. r^2 = coefficient of determination.

Table 3.6 Values of regression constants in the concentration/discharge relationship $c = a*Q^b$ for selected sediment stations in Ontario (cont.)

Station Name	Drainage Area (km^2)	Record Length[2] (years)	Average Values[3]) a	Average Values[3]) b	r^2 ([5])	Range of Values[4] a max	Range of Values[4] a min	Range of Values[4] b max	Range of Values[4] b min
North Magnetawan River above Pickerel Lake	149	5	12.7	0.31	0.25	16.0	8.8	0.51	-0.17
Nottawasaga River near Baxter	1180	5	4.6	1.01	0.56	5.6	3.7	1.08	0.92
O.A.C. Farm Gauge No. 5 at Guelph	2.51	16	108.4	0.10	0.02	1209	17.1	0.43	-0.26
Ottawa River at Brittania	90,900	6	0.2	0.54	0.17	12,100	.0005	1.49	-0.89
Saugeen River near Port Elgin	3960	7	6.7	0.45	0.24	23.8	0.8	0.86	0.17
South Nation River at Casselman	2410	7	8.5	0.34	0.54	11.9	1.5	1.03	0.25
South Nation River near Plantagenet	3810	16	19.4	0.31	0.31	65.2	5.8	0.78	0.10
Sturgeon Creek near Leamington	14.2	6	231.6	0.62	0.39	422.7	127.0	0.82	0.48
Thames River at Ingersoll	518	11	11.7	0.46	0.30	19.5	6.4	2.24	0.28

Notes:
1. The stations listed are those with at least 5 years of continuous or seasonal records and load calculations.
2. The record length refers to pre-1988 data.
3. Average values are based on regression analysis of all available data.
4. The values listed under Range of Values are based on a seperate analysis for each year of record.
5. r^2 = coefficient of determination.

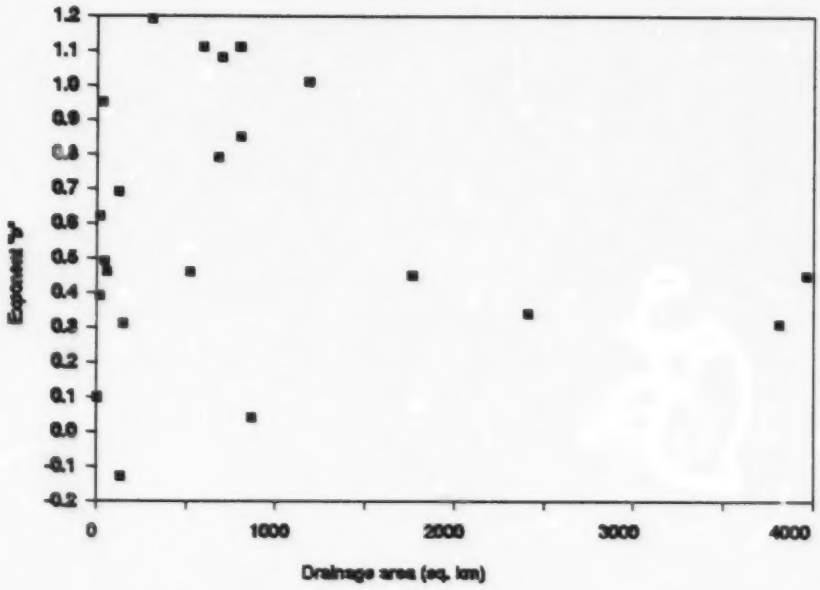

Figure 3.13 Value of the exponent "b" (in c = a*Q^b relationship) plotted against drainage area, for 22 stations with at least 5 years of continuous or seasonal record. (Ottawa River at Brittania: drainage area 90,900 km^2 is not plotted.)

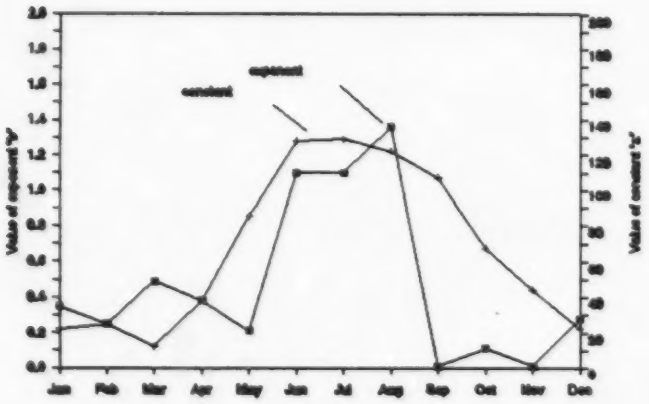

Figure 3.14 Seasonal variation of the constant "a" and the exponent "b" of the concentration/discharge rating relationship for the Ausable River near Springbank.

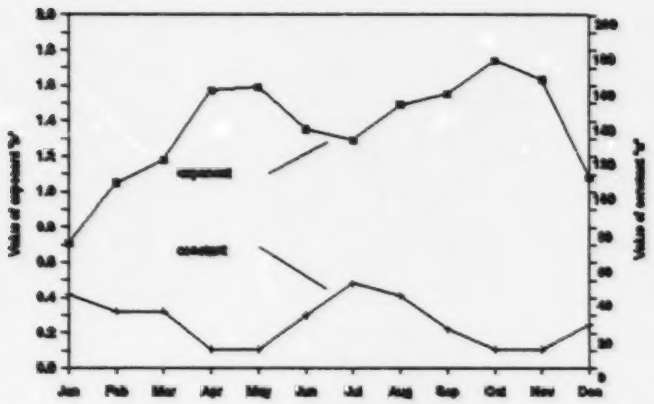

Figure 3.15 Seasonal variation of the constant "a" and the exponent "b" of the concentration/discharge rating relationship for the Humber River at Elder Mills.

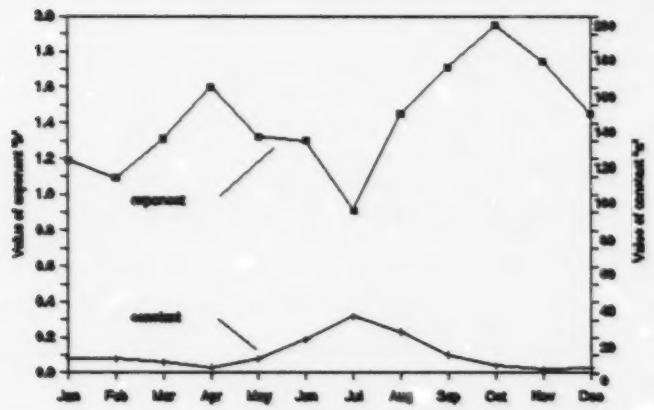

Figure 3.16 Seasonal variation of the constant "a" and the exponent "b" of the concentration/discharge rating relationship for Big Otter Creek near Vienna.

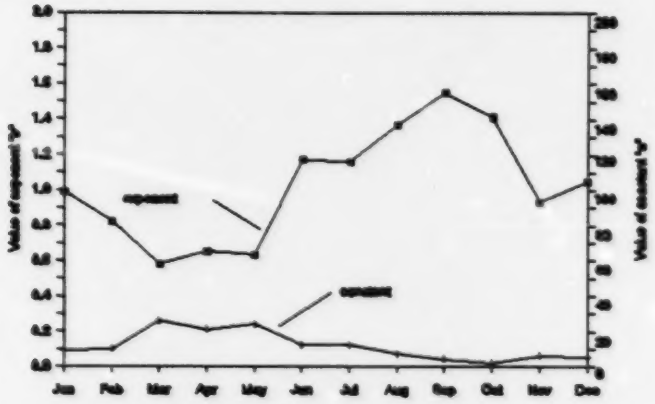

Figure 3.17 Seasonal variation of the constant "a" and the exponent "b" of the concentration/discharge rating relationship for Big Creek near Walsingham.

3.6 Sources of Suspended Sediment Loads

- Can inferences about the sources of suspended sediment be made directly from sediment data available from the Water Resources Branch?
- Do the sources of sediment vary significantly from basin to basin?

The sediment concentration in streamflow is related principally to two governing factors: characteristics of the flow, which determine its ability to maintain and transport a suspension of solid material; and the nature and rate of supply of sediment to the flow. Sources of sediment include the channel bed and bank material, and soil and surficial deposits from valley sides and upland areas of the watershed. If sediment were consistently available for transport (from bed, bank and/or field sources), the concentrations of suspended sediment would depend principally on discharge. In such circumstances, a stream would transport sediment at its capacity rate i.e. the maximum rate possible at each discharge. Although rare, this situation may be realized in alluvial channels, where the streambed materials are noncohesive and not armoured. However, sediment supply to Ontario streams is normally restricted to varying degrees, due to variability in such factors as erodibility of bed and bank materials, and soil erodibility and vegetative cover of fields.

As noted earlier, there is not a fixed relationship between suspended sediment concentration and discharge in Ontario streams. Further, it can be shown that sediment concentrations are much below the transport capacity rate possible at individual stream sites. It is clear, then, that the concentrations of suspended sediment are largely governed by the availability of material from the various sources, and not just the ability of the flow to transport suspended sediment.

The question arises: Can variations in sediment loads in Ontario be explained by variations in geomorphologic, physiographic, climatic, and/or land use characteristics? For example, the higher levels in the South Nation River and Big Otter Creek may be associated with locations on clay and sand plains respectively. The Water Resources Branch suspended sediment data set does not on its own allow detailed exploration of this question. However, reference can be made to some recent complementary studies.

The sediment yield of a basin has been noted in the literature to be a function of a number of factors, including climate, basin geomorphology, soil type and land use. Schumm (1954) and Maner (1958) noted apparent relationships between sediment yield and relief ratio. Williams and Knisel (1971) found that sediment yield could be related to drainage density. However, there appears to be no simple relationship between average annual suspended sediment load and such variables as relief ratio or drainage density in Ontario (Dickinson et al., 1975; Ongley, 1976).

For information in the province regarding the possible relationship of watershed sediment yield to more specific soil and land use variables, one must turn to suspended sediment data assembled in conjunction with the IJC PLUARG studies, i.e. Pollution from Land Use Activities Reference Group. This data set was developed from the sampling of suspended sediments discharged from 11 small (<6000 ha) agricultural watersheds in southern Ontario (Wall et al., 1982). The unit area suspended sediment yields, ranging from less than 100 to 1000 kg ha^{-1} yr^{-1} in a two year study during 1975 and 1976, correspond to the orders of magnitude identified earlier in this chapter and by Dickinson et al. (1975). Wall et al. (1982) found that the annual suspended sediment yield from the 11 small agricultural watersheds could be related to land use and physiographic factors, specifically the percentage row crop in the watershed and the percentage clay in the surface soil. Their relationship was used as a basis for estimating the mean suspended sediment yield to the Great Lakes from Canadian agricultural land to be 201 kg ha^{-1} yr^{-1}. Wall et al. (1982) went further, on the basis of this figure, to estimate the total agricultural suspended yield to the Lower Great Lakes from the Canadian side to be Approximately 650 x 10^3 t/yr.

Variations in the PLUARG watershed sediment yields were further attributable to differences in the quantity of sheet and rill erosion, in the sediment transport systems, and in the amounts of streambank erosion. To explore the relative significance of some of these sources, sediment yields were partitioned into streambank and cropland yield components (Wall et al., 1982). The results revealed considerable variability from basin to basin with regard to both the absolute and relative quantities of sediment yielded by the watersheds. However, it became clear that the bulk of suspended sediment in rural southern Ontario streams emanates from cropland, with sediment delivered from sheet and rill erosion contributing 70 to 100% of the annual load. Bank erosion was estimated to contribute between 0 and 30% of the annual sediment load. Watersheds with highly erodible soils, erosion-sensitive land uses, and an efficient sediment transport system generate relatively high sediment yields; and the lowest yielding basins are those with soils that are not prone to erode, land uses that protect the soil against erosion forces, and features that minimize sediment transport. Factors such as stream buffering by grass or trees and low stream channel density appear to have considerable effect on the determination of sediment yields, causing areas with highly erodible soils and erosion-sensitive land uses to yield surprisingly low sediment loads.

The PLUARG studies, like the earlier-noted results in this section, also revealed that about 75% of the annual suspended sediment yield is transported in February, March and April. Streambank erosion is also maximum during this period (Knap and Mildner, 1978).

A post-PLUARG erosion and sediment modeling exercise, undertaken by Dickinson and Pall (1982), and involving GAMES (the Guelph model for evaluating the effects of Agricultural Management systems on Erosion and Sedimentation), explored spatial variations in sediment yield and identified potential sources of significant suspended sediment. Coleman (1982) employed a similar but more qualitative model on a larger basin in the same area. The results of this post-PLUARG study have generated many insights into the generation of suspended sediment loads in rural parts of southern Ontario. Although the average sediment yield per unit watershed area for the study area, a group of Thames River agricultural watersheds, was not large (i.e. 0.8 t ha^{-1} yr^{-1}), the suspended sediment amounts estimated to be yielded by field-sized areas within the small watersheds were extremely variable (i.e. 0 to 14 t/ha for the spring months), particularly in the more rolling upland watersheds. It followed from these results, that a majority of the suspended sediment leaving the upland watersheds emanates from a very small percentage of the area. For example, 62% of the spring sediment load in one basin is generated in 15% of the area (14% generated in 1% of the area); 55% of the spring load is another basin is generated in 9% of the watershed area (35% generated in 4% of the area); and 71% of the spring load in a third basin is generated in 19% of the watershed area (23% generated in 2% of the area). Sediment yield from flatter lowland areas was found to be much more uniformly distributed.

The models and applications of Dickinson and Pall (1982) and Coleman (1982) are the most definitive to date to link suspended sediment yields in Ontario to watershed physiographic and land use factors. These models and others are presently undergoing extensive verification in a number of locations in the province. However, only after further testing in a yet wider variety of conditions, will the existing models or modifications of them be broadly applicable for estimating sediment loads and sources.

Very few detailed studies in relation to physiographic and land use variables have been undertaken in northern Ontario conditions (e.g. Lane, 1971; Carson et al., 1973). When PLUARG projects in northern basins revealed extremely low suspended sediment loads, no more detailed studies were undertaken. Therefore, the relative impacts of bank erosion and of typical northern land use development (e.g. timber cutting) on downstream sediment loads are not well documented.

From this brief overview of the literature regarding spatial variability and sources of suspended sediment in Ontario, it can be concluded that the long- and short-term sediment records which have been available from various provincial sources have provided useful information for the development of a preliminary picture of the spatial distribution of sediment loads. Although significant progress has been made in understanding linkages between some physiographic and land use factors and associated sediment yields, it is not yet possible to estimate stream sediment loads with sufficient reliability in terms of measurable watershed parameters. Therefore, there is a need to continue to collect good sediment data, and to strive to develop generalized spatial patterns and cause-and-effect relationships between sediment and other variables in order to optimize the use of monitored data and minimize the number of additional sediment stations required.

3.7 Particle Size Distributions of Suspended Sediment

- What is the particle size distribution of suspended sediment in Ontario streams?
- Does the distribution vary significantly from basin to basin?
- Can the source of the suspended sediment be ascertained from the available particle size information?

The particle size distributions of suspended sediment samples are published for several Ontario streams, as listed in Table 2.1. Additional analyses which have been performed at six stations include plots of percentage of silt and clay in the sample against concentration, and against discharge, and plots of median particle size (d_{50}) and "grading" (square root of d_{90}/d_{10}) against discharge. In this section, both the observed size distribution curves, and the available plots of size distribution characteristics are considered.

The size classification system adopted by the Water Resources Branch is given as follows:

Clay:	0.00024 to 0.004 mm
Silt:	0.004 to 0.062 mm
Sand:	0.062 to 2.0 mm
Gravel:	2.0 to 64.0 mm

The particle size distribution curves demonstrate a wide range of behaviour, both between streams and on the same stream. However, examination of a few stations with many particle size analyses suggests that some features are common to most streams. The following comments apply to streams in the Great Lakes/St. Lawrence Lowland, since the only station with a size distribution analysis outside this region is on the Pic River near Marathon, with only one sample analyzed. First, gravel appears to move only as bedload, since no suspended sediment samples have included material coarser than sand. Second, the median particle diameter of most samples on most streams is within the silt range. Third, all samples contain material from each of the three fractions: clay, silt and sand. Clay and silt dominate most samples, with silt usually accounting for about half the sample, and sand accounting for less than 10%. Some variation in the dominant fractions between streams is apparent. Samples taken from the Ausable River are dominated by clay (60% approximately), and sand represents less than 5% of most samples. On Big Creek, however, the clay component is usually only about 20% of the sample, and sand accounts for an average of about 30%. This difference is attributable to Big Creek rising in a sand plain.

Some streams are more variable than others. Big Creek shows relatively consistent behaviour, at least in the smaller sizes, with clay ranging between about 5 and 35% of the sample. Conversely, the O.A.C. Farm Gauge shows extreme variability, with the clay fraction ranging from about 10% to 85%, and the sand fraction ranging from 0% to about 70%. A typical range on most streams would be: for clay, about 10% to 60%; silt, 20% to 70%; and sand, 0% to 40%. Variability on each stream is largely due to variations in both discharge and sediment availability. Variability between streams is mostly due to differences in source characteristics. However, differences between streams are difficult to characterize because of the large within-stream variability.

Plots of size distribution characteristics against concentration and discharge are available for only six streams. Examination of these plots reveals a high degree of scatter. Although not subjected to statistical analysis, most plots show inconclusive relationships with non-zero slopes, indicating very weak and variable relationships.

An understanding of how streamflow, sediment sources, and other factors influence the size distributions of suspended sediment is important in understanding the reasons for the wide variability in behaviour, and the absence of well-defined relationships. As noted in Sections 3.2 and 3.6, the concentration of suspended sediment is largely determined by flowrate and sediment availability. These two factors also affect the size distributions of the suspended sediment. Sources of sediment for most streams consist of material stored in the channel bed and bars, channel bank material, and soil eroded from the watershed surface and delivered to the channel by overland flow. The in-situ material from each of these sources is different, and size distributions of sediment samples reflect the characteristics of the contributing sources.

Hydraulic considerations indicate that larger flowrates are able to bring larger particles into suspension. Therefore, if sediment were readily available from a single source, there would be a direct relationship between discharge and the median particle size (d_{50}) of suspended sediment. Similarly, the silt and clay proportion of the sample would decrease as both discharge and sediment concentration increase. Such relationships are evident on some streams. However, they are always confounded by source variability, which introduces large scatter, and may even change

the direction of the relationship from direct to inverse. Hysteresis in the discharge-concentration relationship may introduce a further complication. Concentrations tend to be higher on the rising limb than on the falling limb of large flow event hydrographs because of steeper water surface slopes, and greater sediment availability. This factor may also affect the size distributions of suspended sediment, and add to the observed variability.

In summary, some features of particle size distribution curves are common to most streams in Ontario. Samples always contain elements of each of the three fine size classes: clay, silt and sand; and the median particle size is usually within the silt range. In general, sand represents less than 10%, and silt represents about 50% of the sample. On streams with many samples analyzed, it is possible to detect differences between streams, such as the Ausable River and Big Creek. In general, however, the range in behaviour on each stream precludes definitive comparisons between streams. Typically, the observed ranges on each stream are about 10% to 60% for clay, 20% to 70% for silt, and 0% to 40% for sand. Plots of size distribution characteristics against concentration and discharge reveal very weak relationships, with a high degree of scatter. These results lead to the conclusion that the characteristics of suspended sediment samples depend somewhat on discharge, but depend mostly on sediment sources, and on their spatial and temporal variability.

3.8 Accuracy and Precision

- Can the data user be sure that suspended sediment concentration and load values are accurate and reasonably precise?
- What are the main factors contributing to errors and imprecision?

The processes of sediment delivery to streams, sediment entrainment from the beds and banks of stream channels, and sediment transport are complex processes which operate continuously in time and space. The objective of the Sediment Survey sampling program is to obtain enough discrete information from the continuous record, at locations of importance in relation to human activity, to reliably describe the sediment regime. Sampling strategies are designed (and continually refined) to preferentially obtain data of maximum value.

The process of collecting and analyzing sediment data involves several steps at which measurement and computational errors may be introduced. Although a comprehensive analysis of the accuracy and precision of published sediment data has never been conducted in Canada, it is possible to summarize the possible sources of error and qualitatively assess their significance. Errors may be associated with the following aspects of the Sediment Survey program:

1. frequency and timing of sampling,
2. field equipment and measurement techniques, and
3. laboratory analysis techniques for determining concentrations and particle size distributions.

In addition, the calculation of sediment loads involves the following additional sources:

4. interpolation, to determine a continuous record of sediment concentration, and
5. determining the continuous discharge record from the water level record.

As noted earlier, sediment load duration data in Ontario consistently show that a very high proportion of the total annual load is transported in a very few days each year. Therefore, sampling strategies have been designed to concentrate on the periods when flows, concentrations, and loads are expected to be high. The major implication

of the extremeness of the sediment regime is that significant errors can be introduced unless concentration measurements are obtained for the 30 or 40 highest sediment load days each year. Conversely, if the main suspended sediment load events are sampled well, the sampling effort for the remainder of the year, when flows, concentrations, and loads are low and stable, can be minimized without serious introduction of error (Dickinson, 81).

Normal experimental error is associated with the use of sampling equipment, and with field measurement, and laboratory analysis techniques. Several sources of information on the accuracy and precision of equipment and techniques used by Sediment Survey are available from offices of the Water Resources Branch.

The process of interpolation of the concentration curve between measurement points is a subjective process, relying on experience and judgement. The availability of data during key periods greatly increases the accuracy of the interpolated curve. In addition, the concentration record is plotted on the water level record, not on the discharge record. In general, discharge is exponentially related to water level, with an exponent greater than 1; i.e. discharge is more extreme than water level. Second, concentration is in turn exponentially related to discharge, with a positive exponent, causing concentration to be more extremal than both discharge and water level. The present procedure of interpolation, therefore, may lead to somewhat low estimates of suspended sediment loads during peak flow and load periods, unless sufficient suspended sediment concentration samples are available at or near the peak.

In summary, it is difficult to make definitive statements of the accuracy and precision of suspended sediment load data. However, it is clear that sampling frequency, particularly in relation to the brief period each year when suspended sediment concentrations and loads are high, is critical to the achieving of accurate estimates, as is the appropriate interpolation of concentration values between sampled points. As attention is paid to such portions of the process for estimating suspended sediment concentrations and loads, it is believed that bias has been minimized and reasonably precise determinations achieved.

3.9 Sediment Loads and Water Quality

- Do sediment loads play an important role in the transport of other contaminants?
- Is sediment a source of, or a sink for, contaminants?

The International Joint Commission report on "Pollution in the Great Lakes Basin from Land Use Activities" (I.J.C., 1978) reported: "PLUARG finds that the Great Lakes are being polluted from land drainage sources by phosphorus, sediments, some industrial organic compounds, some previously-used pesticides, and potentially some heavy metals. ... Sediment affects the Great Lakes system primarily as a carrier of phosphorus and the other contaminants, contributing to the overall pollution of the lakes." These summary statements from the PLUARG findings, identifying suspended sediment as a prime transport medium for the delivery of pollutants, have placed sediment and programs for its measurement and control in a new, higher level of importance. What do we know about sediment as a transport medium? What are the ramifications for sediment monitoring programs?

Sediment on the one hand can be a pollutant carrier or source, and on the other a pollutant sink or trap. This phenomenon applies to virtually all pollutants mentioned above by PLUARG, and depends to a great extent on the chemical conditions in the water. In some biochemical situations, sometimes identified with well-oxygenated conditions, many chemical substances become bound to the surface of sediment particles, especially the clay-sized particles. This is the case in agricultural environments for phosphorus, trace metals (e.g. copper, lead, zinc), and some pesticides (particularly the chlorinated hydrocarbons such as DDT and HBC). When these soils erode, the

suspended sediment becomes a pollutant carrier for the bound contaminants, transporting them to downstream locations. If and when such sediment experiences a change in the biochemical conditions in the water, the contaminants may be released more or less quickly, depending on the conditions. In such cases, the suspended sediment has served as not only the carrier but the contaminant source; and such is the case in Ontario for the delivery of phosphorus (Allan, 1979; Logan, 1979; Depinto et al., 1981; Coleman, 1982; Culley et al., 1983), trace metals (Miles and Watson, 1977; Ihnat, 1978; Logan, 1979; Whitby et al., 1979; Ihnat, 1982), and pesticides (Miles and Watson, 1977; Burton, 1978) from farmlands to streams and lakes.

Relatively contaminant-free sediment may also act as a sink in some biochemical water conditions, contaminants from other sources and travelling in solution becoming bound to the available sediment. This situation has been observed in the Detroit and Niagara Rivers (Frank et al., 1977; Warry and Chan, 1981; Fox et al., 1983; Halton, 1983; Kuntz and Warry, 1983), where organochlorine insecticides and PCBs have become bound to the sediment; and in northern rivers, including the English-Wabigoon (Bahnick et al., 1978; Rudd and Turner, 1983), where mercury, copper, manganese, nickel, zinc and lead have been scavenged by the sediment. If the biochemical conditions remain similar where the sediment ultimately settles out, the contaminants may remain bound to the sediment and it remains a sink. However, should biochemical conditions alter sufficiently, be it in stream, harbour, lake bottom or during resuspension, the sediment material could revert to being a source of contamination.

Much has been learned about many of the contaminants which are associated with stream and lake sediments in Ontario, and a start has been made in understanding the processes involved in the binding and/or releasing of the contaminants from the sediment particles. However, knowledge regarding the spatial and temporal variability of these linkage processes as a means of managing pollution, is yet in its infancy. The amount of data appropriate for exploring the linkages between sediment and most of the contaminants has been sparse or non-existent, and the number of carefully structured studies has been few.

In light of the urgency associated with the determination and control of contaminant loads associated with suspended sediment, and due of our obvious elementary state of knowledge in this area, it is vital that carefully conceived data sets involving sediment quantity, various contaminant, and other biochemical variables be assembled for studies to ascertain the nature of linkages among the variables and the manner in which these linkages vary in time and space in stream and lake systems in the province. Once such linkages have been established, then combined sediment and water quality sampling strategies will have to be devised for the efficient and accurate estimating of not only sediment concentrations and loads but also various contaminant concentrations and loads.

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